UNIT SIMULATION TRAINING SYSTEM AFTER ACTION REVIEWS (AAR): A NOVEL APPROACH TO ACHIEVE EFFECTIVENESS

By

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Abstract

An After Action Review (AAR) is the Army training system's doctrinal feedback mechanism. The purpose of the AAR is to improve collective (unit) and individual performance in order to enhance organizational readiness. It is a learning process. While the literature discusses instructional and training systems, neither the AAR process nor AAR systems have been examined in terms of learning effectiveness and efficiency.

In this thesis, four elements that combine to produce an effective AAR (one in which the trainees learn) are derived from the literature. A methodology to measure AAR effectiveness with respect to these elements is applied to 17 Combat Training Center AARs. Results of this research suggest that AAR effectiveness can be improved. An approach based upon "guided discovery learning" that takes advantage of current advances in training simulation technology is presented for implementation within the Army training system. Research suggests this approach will facilitate learning from a recent training experience and enhance the effectiveness of the AAR.

To those who train to learn,
may they never have to
give their lives in vain.

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LIST OF ABBREVIATIONS

A

AAR – After Action Review
ACR – Advanced Concepts and Requirements
ADCATT – Air Defense Combined Arms Tactical Trainer
ADCST – Assistant Deputy Chief of Staff for Training, US Army
AI – Artificial Intelligence
ARI – Army Research Institute
ARTBASS – Army Training Battle Simulation System
ARTEP – Army Training and Evaluation Program
ATAFS – Army Training Analysis Feedback System
AVCATT – Aviation Combined Arms Tactical Trainer

B

BCTD – Battle Command Training Directorate
BDA – Battle Damage Assessment
BOS – Battlefield Operating Systems

C

CALL – Center for Army Lessons Learned
CATT – Combined Arms Tactical Trainer
CCTT – Close Combat Tactical Trainer
COL – Colonel
CMTC – Combat Maneuver Training Center
CTC – Combat Training Center

D

DA – Department of the Army
DCST – Deputy Chief of Staff for Training
DIS – Distributed Interactive Simulation

E

EAC – Echelons Above Corp
ENCATT – Engineer Combined Arms Tactical Trainer
ENDEX – End of Exercise

F

FC – Field Circular

FM – Field Manual

FSCATT – Fire Support Combined Arms Tactical Trainer

Ft – Fort

G

GOMS – Goal-Operator-Method-Selection rule

I

IN/Inf – Infantry

IST – Institute for Simulations and Training

J

JRTC – Joint Readiness Training Center

M

MILES – Multiple Integrated Laser Engagement System

MTP – Mission Training Plan

N

NSC – National Simulation Center

NTC – National Training Center

NAWCTSD – Naval Air Warfare Center Training Systems Division

O

OPFOR – Opposing Force

P

PC – Personal Computer (also: patrol cap)

PVD – Plan View Display

R

RDA – Research, Development, and Acquisition

REALTRAIN – Real Training

S

SAF – Semi-Automated Forces

SCOPES – Squad Combat Operations Exercise (Simulation)

SIMNET – Simulation Network

STAARS – Standard Army After Action Review System

STRICOM – Simulation, Training, and Instrumentation Command

STRIPES – Simulation Training Integrated Performance Evaluation System

T

TC – Training Circular

TEMO – Training Exercises and Military Operations

TES – Tactical Engagement System

TF – Task Force

TRADOC – Training and Doctrine Command

TV – Television

U

UCF – University of Central Florida

UPAS – Unit Performance Assessment System

USAIS – US Army Infantry School

V

VCR – Video-camera Recorder

VIF – Variance inflation factor

W

WF – Warfighter

PREFACE

Revolution in Military Training

Since the early 1970's, the US Army has experienced a revolution in training for war that has increased its effectiveness many fold. This increase in training effectiveness is revolutionary because, for the first time in history, an army has the capability to accurately assess its own performance and then implement changes to improve. Prior to this, accurate training assessment depended upon the experience of the leader in charge. This revolutionary ability can be directly attributed to an enhanced combat simulation capability, a standardized and performance-oriented task-based training language, and a formalized mechanism for performance feedback. The most apparent result of this revolution is the Combat Training Centers (CTC) in Ft Polk, LA, Ft Irwin, CA, and Hohenfels, FRG. These CTCs provide realistic conditions and prompt performance feedback for units training there. The CTCs are the most effective training systems the US Army has ever devised and they were a major factor in the Army's success in Panama and Iraq.

Prior to the mid 1970's, training was characterized by three conditions. First, training conditions were unrealistic compared to actual battlefield conditions. Second, unit actions were ill-defined in terms of individual and collective tasks and had

correspondingly vague performance standards. Third, performance feedback was nonstandard across the Army. While objective performance feedback and assessments were provided to individuals in the form of a critique, collective feedback and assessments were based upon subjective and vague criteria such as the amount of noise a unit produced during an assault. (Collins, A. S., 1978)

In the latter half of the 1970's, improvements in combat effects simulation, most notably the laser engagement system in use for direct fire, provided realistic performance outcomes. This in turn allowed the units' actions employing those weapons to be verified and validated in peace time training. Heretofore, this verification and validation only occurred in actual combat. In peacetime, this evaluation of performance and its feedback to the training unit was the sole domain of combat veterans whose experience varied to great degrees. Moreover, the realistic execution of individual and collective combat actions during peacetime allowed detailed task analyses to be conducted. This resulted in unit actions being described in terms of collective tasks consisting of supporting collective and individual tasks/drills. This hierarchy of tasks is recorded in the Army's Mission Training Plan (MTP) series of references and is the language (medium of communication) used to assess and effect performance improvement. Consequently, as task execution became more descriptive, performance feedback became more detailed and formalized in delivery. This feedback mechanism, called the After Action Review (AAR), signified the Army's training process as a system. With the integration of

combat simulation improvements, the AAR delivery method evolved from a subjective critique to participatory discussion of performance.

Improvements in computer-based simulator technology will sustain the revolutionary wave in two ways. First, these improvements will have the same impact on command and staff operations as the tactical engagement system technology improvements had on unit combat engagement actions. The increase in realistic simulations will allow command and staff operations to be converted into a task-based knowledge domain. Most importantly, standards of performance can be assigned to these operations and fed back to the units.

The second impact of improved simulator technology is its enhancement of the feedback and feedback mechanism. Technology improvements allow more performance data to be collected and presented at a faster rate than ever before. Hence, these improvements directly affect the AAR's preparation effectiveness (collecting and presenting the important data) and efficiency (sooner rather than later).

These conditions have placed the Army in a propitious position for further improvement and participation, as an agent of change, in the early stages of a nationwide educational revolution.

Revolution in Learning

With guided discovery learning, the military is unobtrusively on the crest of a revolutionary wave in education. Since still early in evolution, it is probably more

appropriate to say that military research and development funds provide the sustaining energy to the wave. With current budget cuts and military draw-down, the sustenance has been reduced to a number of iterative efforts producing only small wave action. As these choppy research efforts converge and diverge outside the foundations of our nation's educational edifice, the walls are also being worn from within. Most of this internal strife centers on *what* is learned. This strife is a constant drain and source of divergence for the revolutionizing wave of *how* one learns. As cognitive learning and meta-cognitive research clarify *how* humans learn, the *what* to learn question will decrease in importance and only surface when a choice of subjects is available. The *how* will also define what tools are needed to learn.

Notwithstanding the current situation in civilian education, the Army training system can improve and provide a path to follow. The AAR is the Army's mechanism to improve readiness and correct performance deficiencies. Indeed, the AAR is the mechanism by which individuals and units learn. This thesis proposes a novel approach to increase the effectiveness of Army AAR by employing a meta-cognitive instructional strategy and utilizing the advantages provided by computer-based simulation training systems.

Organization of the Thesis

As with most at the masters level, this thesis is an iterative and exploratory effort. Chapter I explains the background and definition of the AAR. How the AAR fits into the

Army training system, its origins, and its doctrinal definition are outlined. The sources drawn upon for this information are Army doctrinal references (field manuals and training circulars) and a number of references from the US Army Research Institute (ARI). Personal communications with first hand sources were also used. Dr. Robert Sulzen, ARI Ft Benning, GA field office, and Dr. Larry Meliza, ARI Orlando, FL field office, provided both color and context to the references and technical reports concerning the AAR's origins and early research.

Chapter II reports the literature review to determine what makes an AAR effective. This research considered the purpose of the AAR in light of AAR research, performance feedback (behavioral psychology), and cognitive learning theory literature to determine the elements of an effective AAR. Most of the AAR research was conducted or contracted by ARI. AAR literature review research has been recently contracted by the US Army STRICOM. Personal subject matter experience is also cited to confirm or question the findings of the review. The elements required to produce an effective AAR are stated.

Chapter III defines the problem. The AAR's current state and condition are described by reviewing what the components of an AAR are at the CTCs and in small unit simulation training systems. AAR systems at the JRTC and National Training Center (NTC) are outlined. Additionally, the Close Combat Tactical Trainer (CCTT) and the Simulation Network (SIMNET) AAR systems are analyzed with respect to the CTC's needs and the Army's 21st century plan for a standard Army AAR system (STAARS).

The simulation research improvement AAR systems analyzed are the Automated Training Analysis Feedback System (ATAFS) and the Simulation Training Integrated Performance Evaluation System (STRIPES) built by LBM Inc. and AcuSoft Inc. respectively. The sources cited are the CTC AAR guidance documents and the development guidance/design documents for each of the simulation systems. Finally, using the elements of effectiveness derived in Chapter II, a methodology was developed to assess effectiveness in an actual AAR. Seventeen formal platoon and company level AARs, videotaped at the JRTC and NTC, were analyzed.

Chapter IV presents an approach to increase AAR effectiveness in small unit simulation training systems. This approach derives from intelligent tutoring research to teach problem solving and is particularly suited to support simulation based training. A vision of how the approach can be implemented as a system is presented in Appendix E.

Chapter V summarizes the findings and limitations of the research as well as identifies areas of potential future research.

Subject Matter Experience

Throughout this paper, I cite my training and AAR experience to temper the research with reality. This subject matter experience is the result of 11 years of Army service. In that time, I have acted in a number of company grade leadership and two battalion level staff positions. In these positions, I have acted as both trainer and trainee in mechanized, air assault, airborne, and light infantry units. The majority of my AAR

experience was gained in the last five years of service. Prior to this, I was assigned to units in which trainiging was not systematic. That is, the unit training systems did not actively employ or accept the AAR as the primary performance feedback mechanism. In the 33 months of two company commands, I conducted and supervised numerous formal and informal AARs. After command, I spent two years at the Joint Readiness Training Center (JRTC) at Fort Polk, LA, as an observer/controller (OC). During this time, I led and facilitated 65 formal AARs and numerous informal AARs.

CHAPTER I

ORGANIZATIONAL SETTING

"The old saying 'Live and Learn' must be reversed in war, for there we
'Learn and Live;' otherwise, we die. It is with this learning,
in order to live, that the Army is so vitally concerned."
— US War Department Pamphlet No. 20-17
July 1945

Learning and the Army Training System

Doctrine

The purpose of the US Army is to maintain peace by deterring war or, if needed, to "reestablish peace through victory in combat wherever US interests are challenged." (Department of the Army [DA], FM 25-100, 1988b, 1-1) Training is the cornerstone that allows the US Army to achieve its purpose and assigned missions. It is the focal point of peacetime operations and a vital component of wartime operations. Training is the single common thread that runs through, maintains, and strengthens the fabric that is the US Army.

The Army's training doctrine is presented in two references – Field Manual (FM) 25-100, Training the Force, and FM 25-101, Battle Focused Training. FM 25-100 describes the US Army's overarching training doctrine that is applicable throughout the organization; individual through unit level. Its central theme is nine principles of training that define the training management system. These principles are the framework upon which all individual and collective training is constructed. They are used as guidelines for leaders responsible for planning, preparing, and executing training. These principles of training are summarized from FM 25-100 below. (DA, FM 25-100, 1988b, 1-3 through 1-5)

Train as combined arms and services team – this principle acknowledges that success in wartime is dependent upon a number of combat, combat support, and combat service support units within the Department of Defense. The Army has the capability to collectively train the commanders and units who will eventually deploy and fight together. The objective is not to make the battlefield the location where units meet to work together for the first time.

Train as you fight – simply, this is the conduct of training under realistic conditions. The purpose here is to ensure that a unit has practiced all the actions it will execute in combat prior to arriving on the battlefield. Critical to this principle is the identification of the differing conditions that a unit may face in combat.

Use appropriate doctrine – this ensures that units are familiar with and follow common procedures and uniform operational methods that will minimize reaction time to

unforeseen situations. It also provides a common framework on which to plan, prepare, and execute operations. In short, it puts all individuals and units on the same sheet of music.

Use performance-oriented training – this principle emphasizes a hands-on approach in practicing the critical tasks and missions that will be required in combat.

Train to challenge – this principle requires training conditions to be intellectually and physically challenging in order to excite and motivate soldiers, hone their skills, and increase their capacity for achievement.

Train to sustain proficiency – this dictates that individual and collective training must be conducted at a frequency and to the standards necessary to prevent skill decay, reinforce teamwork mechanisms, and train new people. The purpose of this principle is to ensure that unit performance is maintained within "band of excellence" over time. The "band of excellence is an ideal range of performance defined by the unit commander. Personal experience has shown that the "band of excellence" boundaries are defined subjectively and in many ways by different commanders. Most commanders will not explicitly define the minimum requirements at all.

Train using multi-echelon techniques – emphasizes maximizing the effective use of training resources by training on different levels simultaneously. Training events must be structured to provide critical task practice for soldiers, leaders, and the sub-units within a parent unit. This approach is the most efficient for training individual and collective tasks associated with a specific critical combat function, task, or mission.

Train to maintain – emphasizes training to achieve technical proficiency on and serviceability upkeep of military equipment and weapons such that they are ready for war.

Make commanders the primary trainers – this principle requires that the unit leaders be held responsible for the training and performance of their soldiers and subordinate units. The unit leader must analyze the wartime mission requirements, indicate applicable Army performance standards, assess the current level of proficiency, coordinate and provide the needed training resources, and develop and execute tailored training plans that produce proficient subordinate individuals and units.

FM 25-101, <u>Battle Focused Training</u>, was written for the leaders responsible for training at battalion level and below. These leaders are both commissioned and noncommissioned officers at squad, platoon, company, and battalion levels. FM 25-101 builds on the doctrine in FM 25-100 and provides practical "how to" guidelines for leaders. (DA, FM 25-101, 1990, Foreword) It describes how to focus a unit's training plan on the specific tasks that the unit is most likely to perform in combat. This is the "battle focus" of a training plan. This concept recognizes that units do not have the time nor resources to train for every task and situation that may arise. (DA, FM 25-101, 1990, 1-10)

Army training tasks are divided into individual and collective tasks; each has specified quantitative and qualitative performance measures and execution standards associated with it. Individual tasks are further subdivided into soldier and leader tasks.

These individual tasks combine with drills to make up collective tasks. Drills are collective tasks that consist of sequenced individual tasks performed by a unit in response to a specific battlefield cue. Collective tasks do not require a specific sequence but do require the unit leader to make one or more tactical decisions. A collective task may also be reliant on other collective tasks. The performance measures and task standards are essential to define "what" is being trained to what proficiency level. Performance feedback and training outcomes are described in these terms.

Once the critical tasks to be trained are identified and the nine training principles are applied to plan, prepare, and execute the training, an After Action Review (AAR) is conducted. The AAR is the "feedback mechanism that leaders use to keep the [training] system dynamic and capable of continual improvement and fine tuning." (DA, FM 25-100, 1988b, 1-9) It ensures that performance feedback is provided to the individual/unit executing the training. This is the key element that closes the loop in the Army training system. It allows units to improve performance by identifying mistakes/weaknesses, causes, and the appropriate corrective actions.

To improve performance, the US Army relies on each unit and individual to learn by rigorous practice (to established performance standards) and reflection on experience. The AAR provides a standard mechanism with which to learn. This mechanism's method is also standardized to establish a common framework for learning. The specific method of learning, advocated by doctrinal training references, is a form of guided discovery learning. Currently, guided (or tutored) discovery is the most efficient learning

method and has been shown to be more effective than learning through instructor critiques. (Williams, 1996a; Smith-Jentsch et al., 1996; Kozlowski et al., 1996; O'Malley, 1995; Chapman & Allen, 1994; Anderson, 1993; Lajoie & Derry, 1993; Katz & Lesgold, 1993; Newman et al., 1993; Swan & Black, 1993; De Corte et al., 1992; Lesgold et al., 1992; Shute & Glaser, 1990; and Shriver et al., 1975) The author's subject matter experience confirms this method and the basic need for the AAR. Indeed, without constructive feedback, individuals and units will make the same mistakes no matter how many training principles are applied or how battle focused the training tasks are. Units and unit members require an AAR to learn and consequently effect improved performance.

The System Implemented

Today, AARs are an integral part of training at all levels. This is because the Combat Training Centers (CTC) have institutionalized the AAR as part of the training process. The most realistic combat training occurs at the CTCs – the National Training Center (NTC) at Fort Irwin, California, the Joint Readiness Training Center (JRTC) at Fort Polk, Louisiana, and the Combat Maneuver Training Center (CMTC) at Hohenfels, Germany. These training centers evolved out of the Tactical Engagement System (TES) concepts of the 1970s. The CTCs are locations where maneuver brigades consisting of two combat task forces and their combat support and combat service support units can immerse themselves in a simulated combat environment. Each direct fire weapon system

is instrumented to simulate its signature and effect. Others, such as indirect fire weapon systems require supporting personnel and systems to simulate. Combat arms units can practice most missions and tasks that they may perform in combat with all their weapons and equipment.

The realistic training conditions also include terrain with minimal maneuver restrictions and a highly trained opposing force (OPFOR). Efforts are taken to ensure that the OPFOR is better trained than the unit rotated in for training. The OPFOR also has the advantage of knowing the terrain, whereas the terrain is relatively unfamiliar to the rotational unit. The premise is that a unit will improve more efficiently if they train against a better unit.

The missions conducted against the OPFOR are “free-play” training exercises. Units must analyze their mission with respect to the enemy, terrain, friendly troops, and time available and then devise and execute a plan. At the same time, the OPFOR are given a contradicting mission and must perform the same analysis to formulate their own plan. Realistic engagement outcomes are decided through the use of instrumented weapon systems on each side. These instrumented weapon systems utilize a laser engagement system, a laser strike position referencing system, and sophisticated probability of hit/kill algorithms to arbitrate the engagement outcomes.

Brigades rotate to the CTCs for approximately 30 days each year. The units spend approximately two weeks in simulated continuous combat operations against the OPFOR. During the training period, four AARs are usually conducted by a permanent

cadre of observer/controllers (OC). The OC teams observe events and performance in an effort to completely reconstruct a battle for the AAR. The realistic training, combined with the AARs, make the CTCs the premier training experience of combat forces. Never before have units experienced more realistic training or learned as much from training. Because of routine exposure, units have adopted and institutionalized the battle focused training system with special emphasis on AARs.

The AAR

The AAR is the process through which leaders evaluate and trainees receive feedback during and after individual and collective training. FMs 25-100 and 25-101 are the capstone training references for the Army. They each address the AAR in complementary fashion. The formal doctrinal definition of the AAR is:

> a method of providing feedback to units by involving participants in the training diagnostic process in order to increase and reinforce learning. The AAR leader guides participants in identifying deficiencies and seeking solutions. (DA, FM 25-101, 1990)

FM 25-100 explicitly states that the AAR:

> is a structured review process that allows training participants to discover for themselves what happened, why it happened, and how it can be done better. The AAR is a professional discussion that requires

the active participation of those being trained. (DA, FM 25-100, 1988b, 5-1)

The training feedback presented in the AAR closes the training system loop and enables units to improve individual and collective task performance. These definitions support the goal of the AAR outlined in Training Circular (TC) 25-20. This goal is to "improve soldier, leader, and unit performance." (DA, TC 25-20, 1993, 1-2)

The Origins of the AAR

S. L. A. Marshall's combat action debriefs of the Second World War and Vietnam were the impetus for the modern day AAR. (Sulzen, R., personal communication, 29 August 1996) His debriefing technique, the "after-action interview," sought to establish the ground truth of a combat event for historical record. (Hackworth, 1967, and Marshall, 1959) The AAR concept was borne out of the combination of Marshall's example and the combat simulation improvements for live, squad training developed in the late 1970's. Specifically, these improvements were the development of effective casualty assessment techniques that introduced objectivity into the training environment. (Zeidner & Drucker, 1988, 186 to 189, and Shriver et al., 1975, 11 and 12) The training tools that accomplished this were the Squad Combat Operations Exercise (Simulation) (SCOPES),

also known as REALTRAIN, and the Tactical Engagement System (TES) that later evolved into the Multiple Integrated Laser Engagement System (MILES) in use today.[1]

The SCOPES was originally developed as a method to evaluate the individual performance under reasonably realistic battlefield conditions. (Shriver et al., 1975, 3 through 4) These tools allowed simulation of realistic battlefield cues and outcomes. Visual and auditory weapon signatures were replicated with smoke cartridges and blank ammunition. For SCOPES (and REALTRAIN), each individual wore an identification number on the helmet. Weapon effects were simulated by the firer calling out the enemy target's helmet (or vehicle) number to a controller. This controller radioed the engagement to an opposing force controller who assessed the casualty/damage.

Later, more accurate effects were simulated by activating a MILES laser transmitter with the weapon system's trigger pull. MILES uses an eye safe laser transmitter to replicate the flight and lethality of a projectile fired from a weapon system. Based on the location and coded lethality of the laser impact, sensors mounted on soldiers and vehicles receive the laser strike and determine if the target is killed, near missed, or unaffected. Hence, units could improve battlefield performance more efficiently by prescribing performance standards that were tied to observable outcomes. (Meliza, L., personal communication, 28 August 1996, and Zeidner & Drucker, 1988, 187)

Prior to SCOPES and the TES, the training of combat units centered on the individual and crew in a school environment.[2] Most training was conducted in a

[1] The REALTRAIN acronym stood for "real training."

"classroom-lecture" format both in a building and outside in bleachers or on the ground. (Zeidner & Drucker, 1988, 146, Collins, A. S., 1982, Chapters 13 & 14, and Shriver et al., 1975, 2) Collective, force on force training outcomes were governed by umpire controllers. They decided the success of an assault on a defended position by subjectively evaluating the numerical superiority, swiftness, and noise level (equated to ferocity) of the attacking unit. Casualties were rarely simulated and units did not practice consolidation and reorganization on the objective. Instead, both attackers and defenders would stand in limbo and wait for the umpire's decision. (Sulzen, R., personal communication, 29 August 1996)

Training feedback was equally nebulous with subjective decisions governing exercise outcomes. After the training, the senior evaluator would critique the unit. He would present his feelings on performance indicating that the unit did well or poorly based on his interpretation of the tactical events. Little objective performance data was identified or discussed. This lecture-formatted critique and the umpire's opinion did not effectively convince units that they had problems that required corrective training. (Scott, 1983, 1 through 2 and Word, 1987, 34)

Such a critique is predominantly a one-way transmission of information that does not facilitate two-way communication. The implied premise of a critique is that the lecturer possesses all the facts necessary for learning. Realistically, it is impossible for any participant or observer to collect enough information to enable 100% reconstruction

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[2] "Crew" refers to a vehicle crew that consists of two to five soldiers depending on the type of vehicle.

of an event in free-play (un-scripted) training exercises. Thus, without interviewing *each* of the participants, the critique becomes grounded in partial facts and assumptions of what happened and why. Recommendations of corrective actions will themselves be partial. Additionally, trainees have difficulty separating criticism from personal character attacks. (Bosley et al., 1979, Preface)

Given such a setting, it is not surprising that research psychologists of the Army Research Institute (ARI) observed excited reactions in soldiers during the initial training tests with SCOPES. For the first time, individual soldiers had control of the weapon system's effect. It allowed him to shoot at an enemy target, score a hit, and remove the opposition from the exercise. After the exercise, the friendly force and OPFOR would engage in animated discussions about the engagement. The seminal elements of the AAR evolved out of the research psychologist's efforts to capture this discussion between the two groups. It was quickly noticed that both the learning rate and level of retention were increased by a controlled discussion between the attacking and defending forces. (Sulzen, R., personal communication, 29 August 1996)

The introduction of reasonably accurate weapon effects simulations, the development of a responsive casualty assessment technique, and the research efforts of ARI allowed trainers to replace the critique with a more effective teaching technique. To differentiate it from the old lecture-format critique, the new training feedback method was labeled the AAR. The AAR was developed to increase teaching and learning effectiveness through soldier participation. (Scott, 1983, 2)

The origins of the AAR are recorded in the Army manuals and research papers describing SCOPES and TES. The AAR was treated as a part of the new combat simulation training techniques but never as an entity to be studied independently. The research on SCOPES and TES was conducted by ARI and/or independent contractors working with ARI. In 1974, the US Army Infantry School (USAIS) published ST 7-2-172, <u>SCOPES, Squad Combat Operations Exercise (Simulation) A System for Realistic Squad Tactical Training</u>. It was one of the first official documents to address the AAR. It briefly describes how an AAR should be conducted, emphasizing involvement of all participants to establish the truth of "what" happened in an engagement. It also discusses the AAR leader's role.

USAIS ST 7-2-172 specifies the leader's role as a discussion facilitator who guides the trainee group through a review of the sequence of actions. Each action is described by the participants in their own words to establish "what" happened for the group. The trainees learn by realizing their mistakes with respect to the situation or training conditions. (USAIS, ST 7-2-172, 1974, 14 and 15) Training conditions are defined in doctrinal terms of mission, enemy, terrain, troops, and time. Specifically, these translate to the task the individual or unit was trying to achieve, the enemy actions that affected performance of that task, the terrain considerations – advantages and disadvantages, other friendly actions that affected performance, and the time available to complete the task.

ARI technical report S-4, REALTRAIN: A New Method for Tactical Training of Small Units, is the first research report on TES during field trials at Wildflecken, Germany in 1975. (Shriver et al., 1975) It restates the method described in ST 7-2-172 and highlights that the AAR is not a critique. It also emphasizes full participation in the discussion and the value of having weaknesses pointed out by the opposing soldiers rather than an observer or instructor. The results of the tests verified that the AAR was a learning medium for the soldiers that reinforced appropriate actions and inhibited inappropriate actions. (Shriver et al., 1975, 23 through 25)

The tests and AARs also highlighted the need for research on the utility of detailed performance measures for tasks within a tactical framework. (Shriver et al., 1975, 23 through 25) This was the first expression of the need for training situations defined by conditions and standards in an official report. This is important because the conditions of training (mission, enemy, terrain, troops, and time) and the explicit performance measures add detail and objectivity to training results or battle damage assessment (BDA). The BDA results serve as points of departure for discussion of cause and effect relationships, weaknesses, and solutions.

ARI Research Report 1219 (1979), Development of Small Combat Arms Unit Leader Tactical Training Techniques and a Model Training System, documents leader training techniques tested for effectiveness in TES exercises. This report is relevant to AARs because it also documents the inability of unit leaders to depart from the critique methodology during training feedback sessions. "Controllers [AAR leaders] did not

appear to be able to reconstruct the battles for the players so that critical mistakes could be identified and positive actions reinforced." (Shriver et al., 1979, 23 and 24) The report goes on to reiterate the guidance found in ST 7-2-172 and Shriver et al. (1975).

Thomas D. Scott, ARI, wrote the Tactical Engagement Simulation After Action Review Guidebook in 1983 and incorporated the findings and research results of the 1970s in this "how to" manual for AARs. Scott outlined procedures for preparing and conducting squad, platoon, and company AARs and contrasted them with those used in the traditional critique. He emphasized that the AAR increases soldier participation and consequently increases: the scope of the AAR, the interpretation accuracy of cause and effect relationships, and the trainees' acceptance of performance feedback. Additionally, he discusses questioning techniques to diagnose training deficiencies. (Scott, 1983) Scott also reproduced the guidebook as a chapter and appendix to ARI Research Product 84-14, How to Evaluate Unit Performance, (1984).

Scott argued that participation increased learning effectiveness from training feedback for three reasons. First, active participation, as opposed to passive observation, greatly increases the amount of information the trainee learns and retains as shown by educational psychology research. Second, trainee participation produces group discussion in which several points of view are presented. This allows the trainees and AAR leader to gain a greater understanding of the problems and their possible solutions. Third, participation increases trainee motivation by providing a sense of ownership in

developing the solutions to identified problems. This involvement also reduces an individual's resistance to acknowledging his own mistakes. (Scott, 1983, 2 through 3)

The Participatory AAR

The participatory AAR provides a broader scope and deeper understanding of cause and effect relationships for identified weaknesses and strengths. Each participant becomes a source of information as well as a problem solver. The critique format limits the discussion points, if there is any discussion, to the type and amount of information gathered by a few observers. The goal is to combine both the observations and expertise of the AAR leader with the insights of the trainees to fully define the actions that influence or determine performance. This combination increases the accuracy of the interpretation of the training event. Furthermore, individuals put the lessons learned into their own words during the discussion which, combined with hearing others talk about the lessons, allows each trainee to learn and remember more. (Scott, 1983, 3 through 4, and Bosley et al., 1979, 4 through 6)

By prompting and guiding discussion so that participants identify and solve the group's problems, the AAR leader avoids the negativism associated with his making declarative statements. The AAR leader asks leading questions of key players of an event to prompt discussion, bring out important information, and make a learning point. Prompting discussion to examine the problem ensures participation and, consequently, avoids the situation of requiring the AAR leader to directly criticize the group. This

criticism is what normally leads to resentment and resistance of the AAR leader to the point where feedback does not occur. "Because the information comes from within the group, hostility and defensiveness usually directed towards the critique leader are minimized." Consequently, the AAR leader can focus the AAR's theme on "how can *we* do it better?" rather than "what *you* did wrong" as is done in a critique. (Scott, 1983, 5 through 6)

Participation is a critical element that has been emphasized throughout the evolution of the AAR. FM 25-101 states that the AAR is a "structured review process that *allows training participants to discover* [emphasis added] for themselves what happened, why it happened, and how it can be done better." (5-6) The manual also outlines an AAR format consisting of four parts: 1) review what was supposed to happen according to the training plan – training purpose and objectives, 2) establish what happened, 3) determine what was right or wrong with what happened, and 4) determine how the task should be done differently the next time. (DA, FM 25-101, 1990, 5-6) This format is "what" must be discussed in an AAR. It is a list of discussion points an AAR leader must facilitate in order to meet the minimum Army standard for an AAR. Except for the recommendation of using leading questions, the manual does not specify the "how." It leaves this up to the AAR leader so that the presentation and methods can be adapted to the trainee audience.

Training Circular (TC) 25-20, <u>A Leader's Guide to After-Action Reviews</u>, is the official supplement to FM 25-101 on AARs. TC 25-20 expands the guidance of FM 25-

101 outlining how to plan, prepare, and conduct an AAR. It gives the definition of an AAR as:

> a professional discussion of an event, focused on performance standards, that enables soldiers to discover for themselves what happened, why it happened, and how to sustain strengths and improve on weaknesses…It provides—
>
> - Candid insights into specific soldier, leader, and unit strengths and weaknesses from various perspectives.
> - Feedback and insight critical to battle-focused training.
> - Details often lacking in evaluation reports alone.
>
> Feedback compares the actual output of a process with the intended outcome. By focusing on the task's standards and by describing specific observations, leaders and soldiers identify strengths and weaknesses and together decide how to improve their performances. This shared learning improves task proficiency and promotes unit bonding and esprit. (DA, TC 25-20, 1993, 1-1)

It also explicitly states that "the AAR is a problem-solving process. The purpose of discussion is for participants to discover strengths and weaknesses, propose solutions, and adopt a course of action to correct problems." (DA, TC 25-20, 1993, 4-4) This is the heart of the AAR. When trainees participate in a discussion to achieve this, learning occurs. When one of the elements of "what," "why," or "how" are left out or trainees do

not participate in the discussion, something less than a complete understanding of the problem and its relative solutions is realized.

Participation is a major theme carried throughout the AAR doctrine. (DA, FM 25-100, 1988b, FM 25-101, 1990, and TC 25-20, 1993) This is highlighted in each chapter of TC 25-20 as methods, techniques, and training aids are described in terms of prompting trainee participation. The training circular maintains that the AAR leader should endeavor to create an atmosphere in which participation is encouraged. The leader does this by entering into the discussion only when necessary, constantly reinforcing the fact that it is permissible to disagree, maintaining a focus on learning, and encouraging trainees to give honest opinions. (DA, TC 25-20, 1993, 4-1 through 4-2)

TC 25-20 lists key points that guide leaders in the conduct of all AARs. These key points expand the description given by FM 25-101 of "what" an AAR should accomplish and how it should support the Army training system as a whole. The key points are summarized as follows: (DA, TC 25-20, 1993, 1-3)

- *AARs should be conducted during or immediately after each critical training event*. Critical events are those events that are key to accomplishing each task to the specified performance standards. (DA, TC 25-20, 1993, 3-1 and 3-2) These critical events are defined by the training plan that consists of the purpose and objectives of the training. The concept behind battle focused training is that a performance weakness is identified and the corresponding training tasks are trained to correct that weakness.

Hence, the critical events are defined by actions that the unit must execute to show proficiency on the tasks associated with the performance weakness.

- *AARs should focus on the intended training objectives.* The AAR leader must not allow issues that are unrelated to the purpose of the training to be discussed. (DA, TC 25-20, 1993, 4-1 and 4-6) The training objectives are explicitly stated in the training plan. The trainer, the leader responsible for training, develops the training objectives from the unit's training needs. Training needs are derived from previous training and other unit assessment tools. They center on performance weaknesses that must be corrected and strengths that must be sustained.

- *AARs should focus on individual and collective performance.* The AAR leader must relate performance to the accomplishment of the unit's training objectives. (DA, TC 25-20, 1993, 4-6) Trainee discussion should be of the actions that were identified as critical by the purpose of training. Simply, the AAR must focus on performance because its overarching goal is to improve performance.

- *AARs relate to specific performance standards.* When the trainer develops the training plan and specifies the training objectives, he also specifies the standards of performance that the trainees must achieve. This requirement keeps the discussion focused on improving the performance that the trainer designed the training exercise for. (DA, TC 25-20, 1993, 2-4 and 3-1) The primary source for the collective task training standards is the Army Training and Evaluation Program Mission Training Plan (AMTP or MTP) series of manuals. The sources for individual task training standards are the

Soldier's Manuals of Common Tasks and MOS (Military Operational Specialty) specific Skill Manuals.

- *AARs involve all participants in the discussion.* When all participants are actively engaged to discover what happened and why, they learn and remember more than they would have if the same information had been presented in a lecture format. (DA, TC 25-20, 1993, 1-2) Furthermore, a greater variety of viewpoints, ideas, and observations are input into the problem solving process. This will ensure that problem areas are more thoroughly defined and solutions completely articulated.

- *AAR leaders use open-ended and leading questions to, respectively, prompt and guide discussion.* This is the technique recommended to get the soldiers to discuss the desired topic. An open-ended question is defined as one to which there is no specific answer but allows the respondent to answer with what is significant to him. (DA, TC 25-20, 1993, 4-3) This motivates the trainee to participate in the discussion because he is allowed to speak about issues that he perceives are important. The trainee is also much less likely to have a defensive attitude. (DA, TC 25-20, 1993, 4-3) Leading questions are those asked about specific issues in order to focus the discussion on specific events and performance. Although TC 25-20 does not explicitly state the relationship, common sense dictates that leading questions should be used to orient the trainee group on the topic and open-ended questions should then be used to discover what happened and why. One aim would be to get the participants, not the AAR leader, to identify the collective

performance weakness and explain the cause and effect relationships in their own vernacular.

- *AARs determine strengths and weaknesses.* Throughout the discussion the AAR leader should note and summarize learning points and performance weaknesses and strengths. (DA, TC 25-20, 1993, 4-7 and 4-8) The intent is to translate training performance into individual, both soldier and leader, and collective tasks with known or specified standards. This, in turn, will define future training objectives and the first portion of the explanation of "how we can do this better."

- *AARs link performance to subsequent training.* AARs afford unit leaders the opportunity to assess unit performance and immediately retrain deficient tasks. In this manner, they provide a direct link between task performance and execution to standard. (DA, TC 25-20, 1993, 5-1) The second portion of "how we can do this better" is defined in the link. The AAR leader must ensure that specific training conditions for the identified deficient tasks are articulated. The performance of the deficient task under the specified conditions should correct the weakness. In essence, the participants of the AAR are designing their next training exercise.

Outlined below is a recommended AAR format proposed in TC 25-20. (DA, TC 25-20, 1993, 1-3 and Chapter 4)

1. Introduction and rules. The AAR leader describes the purpose and sequence of the AAR. He also emphasizes that "the AAR is not a critique" and that all trainees should participate in the discussion to improve performance.

2. Review training objectives and intent. The training objectives, friendly and OPFOR commander's mission and intent, and relevant doctrine, tactics, techniques, and procedures are reviewed.

3. Summary of recent events. Using leading and open-ended questions, the AAR leader guides a discussion of the logical sequence of events.

4. Discussion of key issues. The AAR leader uses one of three discussion techniques to help participants discover strengths and weaknesses, develop solutions, and designate corrective action. The three discussion techniques structures are: a chronological order of events, the seven Battlefield Operating Systems (BOS), and key events/themes/issues.

5. Discussion of optional issues. The AAR leader has the option to lead the discussion to the topics of soldier/leader skills, tasks to sustain/improve, statistics, or other topics.

6. Discussion of force protection issues. This is a mandatory topic. It covers all aspects of soldier safety in the field and in garrison.

7. Closing comments and summary. The AAR leader reviews and summarizes learning points from the discussion and future training tasks and conditions.

TC 25-20 differentiates between two types of AARs – formal and informal. Both types seek to cover the same key points and utilize the same format. The differences are in who leads the AAR, the planning and preparation time, the type of training aids, and the location of the AAR. Formal AARs usually have observer/controllers who are

external to the unit responsible for leading and facilitating the AAR. Formal AARs also are scheduled, take more time to plan and prepare, use complex training aids, and are conducted where best supported. Informal AARs are normally conducted by the internal chain of command of the training unit. They are conducted as needed but can also be scheduled. Informal AARs take less time to prepare, use simple training aids, and are held at the training site. (DA, TC 25-20, 1993, 1-2 through 1-5)

While a formal AAR may appear more organized and well produced than an informal AAR, informal AARs have the advantage of being conducted immediately after training or a critical event during training. This allows performance feedback to be provided while the training is still fresh in the soldier's minds. Doctrine posits that soldiers are more motivated to participate in the discussion and will remember the learning points for a longer period of time. (DA, TC 25-20, 1993, 1-5) This also makes it easier for the leader to reinforce learning points with follow-on discussion and training.

The training aid complexity referenced in the difference between formal and informal AARs refers to the amount of materials and support required to prepare the training aid. The training circular lists the complex training aids for formal AARs as: terrain model, enlarged map, models, dry-erase marker board, photographs, video camera and monitor. The circular lists the simple training aids required for informal AARs as: unit markers, pointer, unit maneuver graphics, communications recordings, rocks and twigs, and colored chalk. (DA, TC 25-20, 1993, 2-6 through 2-7) Obviously, the training aids for formal AARs require transportation support, electricity, and manpower to set up.

The informal AAR aids can be carried and set up by one person and are common to all live training exercises.

Summary

The Army's training system is the tool it uses to achieve the state of readiness warranted by the national objectives. This system is dynamic and must adapt to new or redefined threats to national interests and/or domestic need. This dynamic environment, combined with a constant influx of new (untrained) personnel, requires a training system that can quickly train units to the requisite performance level. The AAR is the Army's doctrinal method of providing training feedback to improve individual and collective performance to that specified level. Stated concisely, the purpose of the AAR is to *improve performance*. The AAR's objectives are to:

- Define the problems that will improve performance;
- Articulate the solution(s), in relation to the applicable battlefield situation, to increase learning; and
- Translate the solutions into future training objectives to reinforce learning.[3]

The goals and policies of the AAR (stated above) are aimed at creating an effective learning environment in order to improve performance efficiently. This

[3] It is important not to confuse the purpose and objectives of the AAR with those of training. The AAR's purpose and objectives never change. The training purpose and objective(s) are mission, unit, and situation specific. In other words, training purposes and objectives are designed to meet a specific training need. The AAR's purpose and objectives are a component of the process used to meet that need.

research is intended to 1) explore whether or not the AAR is implemented IAW doctrine and 2) propose a novel approach for improving the AAR's effectiveness.

CHAPTER II

AAR EFFECTIVENESS

"Our business, like any other, is to be learned by constant practice
and experience;"
— Sir John Moore

What is an Effective AAR?

Previous Work

A review of the AAR literature revealed four sources that discuss the effectiveness of AARs. The first source, John Bosley et al. (1979), Improved Tactical Engagement System Training Techniques: Two Training Programs for the Conduct of After Action Reviews (ARI Research Product), deals with effectiveness in an indirect manner. The other three, Larry Word (1987), Observations from Three Years at the National Training Center (ARI Research Product), Cal Downs et al. (1987), Analysis of Feedback in After Action Reviews (ARI Technical Report), and SHERIKON Inc. (1996), Analysis of AVCATT After Action Review Requirements (contracted research report), address effectiveness directly.

Bosley and his colleagues' efforts are the culmination of ARI and contract research on AARs in support of TES training exercises. (Bosley et al., 1979) They are presented as a training program for small unit leaders conducting AARs. Except for one shortfall, the document outlines many aspects that make AARs effective. One of the significant themes is trainee participation. Bosley et al. state that an effective AAR is one in which the "troops themselves will have reconstructed the exercise (verbally) the way they experienced it, while the AAR leader has helped them connect different parts together into a pattern of cause and effect at the unit level." (Bosley et al., 1979, 6) Bosley et al. conclude that the goal of the AAR summary is to show how prior events and actions led to later successes or failures of the group effort. (Bosley et al., 1979, 11)

The shortfall of the research is its recommendation on how to conclude the AAR. In 1979, the Army's training management system (Chapter I) had not been standardized across the organization. Detailed task analyses had not been published for collective training tasks. Thus, Bosley et al.'s (1979) AAR outline does not end with the development of a corrective training plan consisting of tasks that specifically address performance weaknesses. This does not reflect a lack of thoroughness in Bosley et al.'s research, this is a shortfall in hindsight only.

The second source is <u>Observations from Three Years at the National Training Center</u> by COL (Ret) Larry Word. Word's research product is actually the result of more than a three year tour at the NTC. Previously, he had been a research coordinator with

ARI and had witnessed the AAR's origins in the 1970s. (Shriver et al., 1975) At the NTC, he was the chief OC for mechanized infantry battalions and a key player in the development of the AAR system. (Word, 1987) As of 1992, his AAR guidance, <u>Word's Words</u>, was still used to train OCs at the NTC. (NTC/BDM, 1992) Word was later assigned as the director of the JRTC and helped establish the CMTC. (Word, 1987)

Word emphasized unit participation in the AAR and accuracy of information as the key elements in an effective AAR. His conclusions do not contradict those of Bosley et al. However, he explicitly identifies the OPFOR participating in the AAR as critical to effective learning. The reason for this is that only half the exercise can be *accurately* reconstructed from half the participants. The OPFOR provides the necessary information that allows full reconstruction. (Word, 1987, 32 through 35) On the other hand, Bosley assumes the OPFOR's presence and does not highlight their need nor importance. Word's emphasis makes sense when one realizes that he witnessed some of the first AARs conducted in the US Amy.

Word also stressed that: all members of a platoon should attend and participate in the AAR at that level; the AAR leader must adhere to the format to keep the discussion on track and limit the length of the AAR to a reasonable amount of time; a representation of the terrain is needed to keep terrain considerations at the forefront of discussion; any AAR aids should clarify problem situations and illustrate points rapidly and effectively; and the AAR should conclude with a summary of corrective training tasks to improve performance. (Word, 1987, 28 through 40)

The third source is an attempt at a scientific test of message feedback effectiveness in AARs. Downs et al. performed message content analysis on six battalion staff AARs to evaluate the adherence to principles of effective feedback. The AARs were conducted as part of command and staff training with the Army Training Battle Simulation System (ARTBASS). The content, form (question or comment), level of specificity/detail, and valence (positive/negative nature) of verbal messages uttered during the AARs were measured.

Downs et al. conclude that seven components are necessary for an effective AAR. These are introduction, topics, participation, description, evaluation, goals, and summary. (Downs et al., 1987, B-5) The first is the introduction given by the AAR leader. The introduction is "very" important in setting a participatory climate. Downs et al. state that the climate should be "structured but not intimidating." The research team does not recommend how to achieve this climate other than saying that the AAR leader should have relaxed, engaging, and unthreatening mannerisms. To establish structure they recommend reviewing the "learning agenda" for the exercise and setting the expectancy of the AAR participants for the roles they are to play during the AAR. (Downs et al., 1987, B-1 to B-2 and B-5) Downs et al. do not define what a learning agenda is. They do mention that the learning objectives are a component of the learning agenda. (Downs et al., 1987, B-2) However, an example or definition is not given.

Bosley et al. agree that the introduction is important to the AAR. They state that the trainees should sense a climate of open discussion from the introduction. The unit

should know why they are there, what to expect, and what their role in the process is. (Bosley et al., 1979, 15 and 16) Bosley et al. and Word also recommend stressing the role of the AAR leader as a moderator/facilitator. (Bosley et al., 1979, 16, and Word, 1987, 34)

The second component of effectiveness is the AAR topics to be discussed. (Downs et al., 1987, B-2) The research team identifies the six most common topics discussed but fail to say why they are important to effectiveness. In their executive summary, the team suggests that the most common AAR topics be the source of future training exercise objectives and AAR discussion points. (Downs et al., 1987, viii) In any case, Downs et al. are in direct conflict with Bosley et al. and Word. Both of them say that the topics or performance problems cannot be predetermined and that the participants, not the AAR leader, must discover them. (Bosley et al., 1979, 14, and Word, 1987, 29 to 30 and 33) Bosley et al. and Word realized that every unit in the Army has different strengths and weaknesses at a given period in time. A much larger and more representative sample of units must be used to determine common problem trends. Even when identified, these trends are only valid for the factors (focus of training, prior proficiency levels, training resources used, personnel turbulence, etc.) that defined the training environment at that specific point in time.

Downs et al. identify participation as an "extremely" important component of an effective AAR that is directly related to the atmosphere created during the introduction. (Downs et al., 1987, B-2) Although they do not offer data to support this conclusion, it

appears logical and SHERIKON (1996) did find research to support it. Downs et al. do tie unit participation to the use of "why" (leading) questions by the AAR leader. (Downs et al., 1987, 16)

Downs et al. tracked the number and source (participant) of each utterance, to include the AAR leader. Hence, conclusions about the amount of participation that occurred during the AAR were drawn from the data. Their participation finding and conclusion are summarized below.

> The number of participants and their degree of participation was highly influenced by the individuals leading the AAR sessions as can be seen from contrasting two battalions. Of all six AAR sessions, the AAR leader of Battalion 2 asked the most [leading and open-ended] questions of his personnel and had the highest number of participants. Conversely, the AAR leader of Battalion 4 was among the three AAR leaders who asked the fewest number of [leading and open-ended] questions and had the lowest number of participants. *Feedback should come from multiple sources as opposed to a single source. Participation in the AAR also leads to greater acceptance of evaluative feedback.* (Downs et al., 1987, 21)[4]

While the conclusion (italics) seems obvious, the findings are a bit misleading. Since the study did not allow for the AAR leaders to conduct multiple AARs, the AAR leader is not a controlled variable. Therefore, the certainty with which the level of trainee participation can be attributed to each of the AAR leaders is questionable.

Comparing the actual data of the two AAR leaders renders the justification for Downs et al.'s second statement above. The 2nd battalion's AAR leader asked 199 questions and declared 288 comments. The 4th battalion's AAR leader asked 23

questions and declared 270 comments. (Downs et al., 1987, 19) There was a large variation between the two AAR leaders.

Combining the data of all six AARs indicates that there was a failure across the board to implement the questioning technique to prompt participation. In all, AAR leaders asked 354 questions and declared 1,959 comments. Moreover, Downs et al.'s analysis found that AAR leaders employed leading questions just 15% of the time. (Downs et al., 1987, 19 through 23) Thus, the 2nd battalion AAR leader's performance was an exception rather than the norm.

Comparing the percentage of utterances by participant reveals a clearer picture of the amount of trainee participation that actually occurred. For instance, consider the AAR in which the highest rate of participation was observed – the 2nd battalion's AAR. In this AAR, the AAR leader, OPFOR, and unidentified sources were responsible for 11.3%, 6.2%, and 1.7% of the utterances respectively. Of the remaining 80.8% of the utterances, the battalion and company commanders, 4 of the 20 unit participants, were responsible for 65.1%. (Downs et al., 1987, 11) Thus, counting the AAR leader's questions, more than three quarters of the trainees were involved in less than 16% of the total discussion.

Combining all six AARs, the source and percentage of the utterances are summarized in Table 2.1, Percentage of Utterances by Source for Six AARs. (Downs et

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[4] "Source" and "sources" here refer to individuals attending the AAR.

Table 2.1, Percentage of Utterances by Source for Six AARs

Source	% Utterances
AAR Leader	17.1
OPFOR	7.3
Trainer	6.9
Unknown	2.6
Trainees	66.1
Commanders	53.7
Remainder of Unit	12.4

al., 1987, 11) The poor distribution of participatory remarks by the unit can probably be attributed to a couple of factors. The AAR leaders' inexperience or incompetence at distributing questions amongst the group and/or the authority of the unit commanders intimidating other participants and AAR leaders.

They also emphasize that participation is dependent upon the discussion topic of individual and group performance and the trainees' perception that it is permissible to disagree. (Downs et al., 1987, B-2) They offer no data nor previous psychological studies as evidence of permissive environments facilitating participation or that people are more motivated to speak about performance in feedback contexts. These appear to be logical presumptions that are verified by the experiment and agreed with by both Bosley et al., Word, and SHERIKON's research.

The third, fourth, and fifth components of an effective AAR concern the characteristics of the message itself. Description, evaluation, and goals are required elements of a message for it to be effective feedback. Downs et al. cite a number of psychological research studies for this conclusion. (Downs et al., 1987, 5) Locke, Frederick, Cousins, and Bobko (1983), Kim and Hamner (1976), and Nemeroff and Cosentino (1979) all conducted studies that showed that messages that reference goals in conjunction with messages that provide feedback about specific performance enhance the feedback process and improve subsequent performance. Nadler (1979) and Cusella (1987) indicate feedback that evaluates an action as right or wrong improves performance more than feedback without any evaluative information. There is an inherent problem in requiring verbal feedback messages to contain these elements. It takes education and training to achieve proficiency in transmitting these types of messages. The natural course of action would be to give AAR leaders the feedback training. However, implementing this may cause them to move back toward lecturing the trainees to provide "effective feedback."

Word (1987) and subject matter experience agree that the solution is for AAR leaders to guide and focus the discussion to achieve the desired characteristics. This would mean specifically identifying the strength/weakness, the good/bad behavior or action that was its cause, and the corrective action that will improve performance and achieve the desired result – the goal. (Word, 1987, 34 to 36)

These message characteristics can also apply to non-verbal feedback. Non-verbal feedback consists of audio and video replay of performance, charts and sketches depicting BDA and instances of the exercise, and various statistical and text performance summaries. Word states that AAR leaders must carefully consider the use of each AAR aid to ensure that the desired feedback point is made clearly and effectively. (Word, 1987, 35 and 38 to 39) This is in line with Downs et al.'s requirement for the message to be specific in description, objective enough to measure, and focused on a learning point.

Downs et al. advocate that the last component of an effective AAR is the conclusion. They state that the conclusion must highlight the main points of the AAR and link them to AAR "learning objectives" and training objectives. (Downs et al., 1987, B-5) Bosley et al. and Word both agree with this finding. (Bosley et al., 1979, 19, and Word, 1987, 36)

The final source, Analysis of AVCATT After Action Review Requirements, was a research effort conducted by SHERIKON Inc. Its purpose was to identify AAR requirements for the Aviation Combined Arms Tactical Trainer (AVCATT) relative to the Close Combat Tactical Trainer (CCTT) AAR system and AAR effectiveness research. AVCATT is a virtual simulation training system that will integrate aviation crews in support of maneuver elements in CCTT.

The SHERIKON research team conducted a literature review to determine the requirements for an effective AAR. However, they did not include the work of Bosley et

al., Word, nor Downs et al. They did cover the work of research psychologists to determine if performance feedback is important. These were Alexander, Kepner, & Tregoe (1962), Bessemer, Shlechter, Nesselroade, & Anthony (1995), Hankinson (1987), and Holmes (1976). SHERIKON also reviewed the work of Briggs & Johnston (1966), Cleveland (1985), Cleveland & McGill (1985), Horrocks (1960), Legge, Gu, & Luebker (1991), Meister (1976), and Rosenberg (1960) to conclude how feedback should be presented and why it is effective. (SHERIKON, 1996b, 4 to 8 and 34 to 36)

SHERIKON concluded that there were seven elements that made an AAR effective. These elements are: 1) feedback should only consist of performance outcome data not apparent nor known to the trainees; 2) feedback should be specific in judgment; 3) timeliness of the corrective training; 4) feedback should be visually presented rather than verbally; 5) the training objectives and plans of execution must be clearly articulated; 6) trainees must receive a summary of critical actions and events; and 7) trainee participation in the discussion.

First, trainees require a debrief of the actions and their effects that cannot be readily detected during the exercise. (SHERIKON, 1996b, 34) In other words, trainees require information to fully understand the cause and effect relationships of what happened in order to make behavioral changes that affect performance. It is SHERIKON's position that data should be provided only for the cause and effect relationships that are not readily apparent to participants during the training. (SHERIKON, 1996b, 7) They view AAR performance feedback as redundant when

participants can detect or see the consequences of their actions during training. (SHERIKON, 1996b, 5) They argue that participants should already have the feedback they need to modify behavior.

Bosley et al and Downs et al. do not address what feedback should be presented. Word states: "What we discover in the mission is just some obvious lessons learned. The real critical learning will surface in the AAR." (Word, 1987, 32) Subject matter experience conflicts with SHERIKON's conclusion since each individual is left to his own interpretation of what happened and why. Many training exercises are long and complex enough for participants to forget what they did. In this case, they need the feedback to refresh memory. Everyone benefits from understanding the value of cause and effect relationships with respect to other actions and the overall results of unit performance. The actions whose consequences are visible are often linked to the actions whose consequences are not and vice versa. To establish the relationships, it is often necessary to link the feedback. Also, individuals remember an action differently and may not realize all of the consequences of their actions. Furthermore, an individual/crew's perception of a cause and effect relationship is exactly what is supposed to be discussed to determine what happened and why. They must be able to completely reconstruct this for other participants to benefit. In other words, feedback on actions whose consequences are apparent will positively or negatively reinforce others who perform the same action. They can relate the feedback to their own performance.

The impetus for SHERIKON's conclusion concerning feedback was a study by Alexander et al. (1962) of Air Force air defense operator teams detecting, identifying, tracking, and targeting aircraft. Alexander et al. found that the AAR increased overall average performance gains by a magnitude of 18 times. But those team functions that yielded immediate and observable (apparent) information during their performance were less affected by the AAR feedback than were the functions that yielded less intrinsic or observable information to the trainee. (Alexander et al., 1962, 208 and 210) In other words, when the trainees could immediately observe the effect of their actions, they were able to correct themselves and did not attend to the AAR feedback. When trainees were not aware of the performance outcome of their actions, the AAR feedback (for those functions) had an effect on performance. However, Alexander et al. did not consider nor measure the effect of feedback for functions with observable consequences on other individuals who had to perform the same function. Thus, he could not draw conclusions about the benefit gained from watching and learning how others perform the same task. While the performance feedback in the AAR may be uninteresting and obvious to one trainee, it may benefit another.

The second element of effectiveness that SHERIKON discusses is that feedback must be specific rather than qualitative. (SHERIKON, 1996b, 34) This is so trainee discussion does not focus on the subjective qualities of the feedback. This is what Word advocated and Downs et al. argued feedback message content should be with their experiment. However, SHERIKON qualifies this finding with the results of Meister

(1976). The amount of feedback detail required by the trainees is determined by their collective skill level. Thus, the detail of feedback varies directly with team skill; more skill requires more feedback detail. SHERIKON points out that Meister finds the converse is also true – too much detail will degrade feedback effectiveness and subsequent performance. (SHERIKON, 1996b, 6)

Even though none of the other sources address this issue, personal experience and cognitive research confirms Meister's finding that high performing units require more detail in performance feedback. People solve problems (learn) iteratively by beginning with an analogy to past experience. (Anderson, 1993, Newell, 1992, and Simon & Newell, 1972) Each iterative step requires a specific amount of knowledge units and too many extraneous knowledge units will obscure those needed.[5] Indeed, poorly trained units cannot process nor even understand the relevance of feedback if it is too detailed. As Meister suggests, the unit, if left to their own devices, will probably try to process all the details and fail to identify problems and solutions commensurate with the unit's skill level. That is, if the AAR leader lets the unit proceed down that path. Subject matter experience indicates that it is easy to focus the trainees on a few salient performance outcomes that will lead them to problems and discussion appropriate to their skill level. This is accomplished by simply telling the trainees to ignore the undesirable feedback and saying: "Let's just focus on this (result) relative to that action." This takes their attention

[5] This process is explained in greater detail in Appendix A, Theoretical Foundations.

off the intimidating detail. In fact, the group is usually glad to ignore some detail in the hope that they may find evidence of strong performance.

SHERIKON's third element of effectiveness is the amount of time that elapses from the point of learning a lesson in the AAR to the point when the unit can practice or train to implement the lesson. (SHERIKON, 1996b, 34 to 35) The unit must have sufficient time to reinforce the lessons with correct behavior and rehearsal in order to fully learn from the feedback. Otherwise, the trainees will not fully retain the learning point and its application.[6] (SHERIKON, 1996b, 6) This is an excellent point as it takes the linking of AAR points to training objectives, that Word and Downs et al. emphasize, one step further. For SHERIKON's AAR process then, the next step in the doctrinal training cycle would become the last step of the AAR. The benefit of correcting specific weaknesses immediately is obvious and also proven by Meister's research. (Meister, 1976) The only obstacle would be having the required training resources, including time, to train specific tasks under specific conditions.

The fourth effectiveness finding is that visual feedback is superior to verbal feedback. (SHERIKON, 1996b, 35) SHERIKON cites research done by Briggs and Johnston (1966) to substantiate this and gives two reasons for it. The first is the AAR leader's inability to recognize and communicate the items important to the individuals and unit that will lead to improved performance. This lends weight to Bosley et al.'s and

[6] Empirical evidence for this statement is given in Anderson (1993) and covered later in this chapter and Appendix A, Theoretical Foundations.

Word's defiance of Downs et al.'s presumption that AAR topics can be predicted. (Downs et al., 1987, B-2)

The second is that a picture is worth a thousand words. SHERIKON references the work of Cleveland (1985) and Cleveland and McGill (1985) that shows graphic displays communicate information more efficiently than numerical tables. This was reinforced with the experiments of Legge, Gu, and Luebker (1991) who found that performance with scatter plots showed clear evidence of parallel processing compared to that of the numerical tables which appeared to be processed in a serial manner at a fixed rate. Thus, the human visual system seems to have the ability "to process global pattern features at a glance" while the aural system processes items sequentially at a slower rate. (SHERIKON, 1996b, 6 to 7) Word confirms this in his paper. For example, he states that the best way to point out a navigational problem to someone is to "show his unit steadily moving out of sector on that [plan view] screen." (Word, 1987, 39) A "plan view" is a birds-eye, two dimensional view of an action, event, or situation. It is usually depicted on a large scale map.

SHERIKON's fifth element is that the training objectives and friendly and OPFOR's plans of action must be clearly understood by the participants. (SHERIKON, 1996b, 35) This understanding provides a framework for the unit to identify critical behaviors in terms of what was supposed to happen and then compare them to what actually happened. (SHERIKON, 1996b, 35) This ensures that participants take into account all factors and conditions that influence an identified strength or weakness. It

allows accurate diagnosis of why a set of actions caused a specific outcome. Bosley et al., Word, and subject matter experience verify this important element. (Bosley et al., 1979, 6 and 8, and Word, 1987, 32 to 34) Downs et al. also support this finding but spend more effort emphasizing the AAR leader's questioning technique to achieve a clear understanding of the training conditions.

The sixth element is that the critical events and turning points of the training must be summarized and presented to the participants to aid their recollection of their own actions. (SHERIKON, 1996b, 35) This element of effectiveness is important to defining the cause and effect relationships of trainee actions and battlefield results. SHERIKON identifies this as the starting point for trainee discovery of why something happened and how to do it better. (SHERIKON, 1996b, 36) This element should not be confused with the first, the requirement to provide feedback for actions whose outcomes are not apparent to the trainees. The first element refers to providing performance outcomes (results) for specific actions. These specific actions may or may not be part of a critical event/turning point in the training exercise.

The training objectives combined with the plans of action define the goal the unit was trying to achieve. This combination is an efficient method of focusing discussion upon a problem area where participants can clearly define cause and effect relationships. Bosley et al. and Downs et al. both agree with this finding. (Bosley et al., 1979, 15, and Downs et al., 1987, B-5)

Word agrees but also points out it is only one method of beginning or guiding a discussion. An alternative is to compare what the unit was trying to achieve to a doctrinal solution. Still another method is to use the BDA or other objective performance measures as a starting point. (Word, 1987, 30 and 35) Subject matter experience has indicated that these methods are mutually inclusive. For example, starting with the BDA (the performance outcome), the discussion of what happened and why will logically lead to an examination of the planned actions and then a comparison to a doctrinal solution. Or, a doctrinal solution can be compared to the plan of action initially and then evaluated with respect to the performance outcome. Either way, the doctrinal solution is always discussed to determine the best solution to the problem.

The last element of effectiveness is trainee participation in the discussion process. (SHERIKON, 1996b, 36) SHERIKON echoes Bosley et al., Word, and Downs et al. as they point out that active participation is necessary to provide differing perspectives of the topics, promote the generalization of the lessons learned to a wider range of situations, and increase participant motivation which increases discussion contribution and quality. (SHERIKON, 1996b, 36) SHERIKON also points out that it is the AAR leader's responsibility to guide and focus the discussion on the points that are important and meaningful with respect to patterns of effective and ineffective behavior. (SHERIKON, 1996b, 36)

SHERIKON's research confirms that learning takes place during participatory discussion or, in their words, a "debriefing session." This combined with the finding that

the learning must be reinforced with correct behavior as soon as possible after the discussion seem to be the salient points of their six elements of effectiveness. Subject matter experience supports this position.

Effectiveness Synthesized

The term "effectiveness" is defined as "having the intended or expected effect; serving the purpose." (Morris, W., The American Heritage Dictionary, 1980) Thus, the effectiveness of the AAR is determined by improvement in individual and unit performance. Plainly, this improvement is dependent upon how well the unit can learn from the training experience during the AAR. In turn, how *well* a unit learns depends upon the acceptance or recognition of the learning point by the group and how well they understand/relate the lesson to their own experience.

AAR effectiveness, as shown by the research literature, consists of four elements.

- Participation in the discussion;
- Discussion focus on learning point(s) – problem and solution;
- Learning reinforcement – retraining;
- Time – delay before the AAR, length of AAR, and delay before retraining.

All of these factors were directly identified by Bosley et al., Word, Downs et al., and SHERIKON and are verified by subject matter experience. The other elements emphasized by the sources are supporting actions, techniques, or requirements to achieve one or more of the above factors.

Discussion Participation

Active trainee participation in the AAR was identified as the most important element of effectiveness by all researchers. Participation in the AAR is best when complete. Each member of the training unit, the OPFOR, the unit trainer, and the AAR leader must be included. This will ensure a number of results that will contribute directly to the effectiveness of the AAR. First, it defines how good the second factor, the learning points, are. Full participation allows the "what happened" and "why it happened" to be *completely* and *accurately* reconstructed. With 100% information, cause and effect relationships between behaviors and results are better established. Once the problem is more fully understood in these terms, participants lend multiple viewpoints and considerations to solve the problem. Participation increases the accuracy of problem interpretation such that all facets of the problem are realized, considered, and accounted for. Finally, participation in solving a problem and then developing corrective measures motivates trainees to participate more and leaders to implement the solution.

Behavioral psychologists outside of ARI have verified the importance of full participation in group problem solving research. Hollenbeck et al. (1995) tested a theory of decision making performance for hierarchical teams with distributed expertise. These teams were designed to model military teams in which there are status differences among members, members have differing levels of expertise and knowledge, and one member is held primarily responsible for the decision. Hollenbeck et al. found that problem solving

efficiency and accuracy increased when information was collected and distributed to all team members and when all members participated. (Hollenbeck et al., 1995, 292 to 312)

In 1959, Smith and Kight conducted a study on different effects on problem solving efficiency in training groups. Their findings show that the AAR leader can have some affect on participation. Their data showed that personalized feedback for group members "markedly, and consistently, improved group problem solving efficiency." (Smith and Kight, 1959, 211) Hence, if the AAR leader can verbally laud a soldier for contributing to the discussion, he and the other unit members will be more likely to participate. This responsibility will require a sizable portion of the AAR leader's attention. However, if the AAR leader is conscientiously providing participation feedback, then he is also not lecturing.

Participation also breaks down the group's natural resistance to criticism. When team members are aware of the problem and solution, each member will work to facilitate the solution implementation. Leaders responsible for implementation will perceive the pressure to do so from superiors, peers, and subordinates. This contributes to an organizational environment in the Army that pressures leaders to correct a problem when it is identified without waiting to be told to do so. (Word, 1987, 33, and personal experience) Hence, participation ensures that the problem is fully recognized, alternative solutions considered, and the corrective action implemented.

Two components that researchers have identified affect participation. They are the AAR leader's ability to establish an open, non-threatening climate that encourages

participation and his use of leading and open-ended questions. As Bosley et al., Word, and Downs et al. point out, the trainee's perception that it is permissible to disagree is important to the climate. Additionally, they emphasized the use of leading and open-ended questions to prompt participation in the discussion. This questioning technique can be used to prompt individuals to contribute if they are shy or to ensure that a lesson is fully articulated.

Another key element of participation is the mechanism that the AAR leader uses to guide discussion so that time and effort are not wasted on ineffectual events. This mechanism consists of purpose and objectives and a format for the AAR. The result of applying these discussion guidance mechanisms is that discussion topics on how to improve performance are quickly identified and focused. Tangential and extraneous topics are minimized and discussion focus is sought during the AAR.

Discussion Focus

The discussion is the principal learning medium in the AAR. All researchers highlighted the discussion's components as critical to effectiveness. They agree that the discussion must establish what happened, why it happened, and how to do it better. Indeed, this is the learning point of an AAR. To achieve a learning point, discussion must result in a clear articulation of what happened and why. The training conditions, as well as a plan to reinforce or correct behavior with respect to those conditions must be discussed, considered, and re-discussed. In accordance with doctrine, the plan must

consist of the tasks to be trained, conditions in which to perform those tasks, and standards of task performance. Finally, this plan must be practical in that it is within the capabilities of the unit to execute.

The number of learning points articulated in an AAR does not necessarily bear on its effectiveness. This is because just one realized learning point will improve performance in some manner. The unit skill level, their collective fatigue level and mood, and their perception of the utility of the training will affect the number of learning points they achieve. Additional influences are the complexity of the training; the AAR leader's skill at guiding, moderating, and facilitating discussion; and the clarity and detail of the performance feedback. All of these interrelate to determine how many learning points are produced.

To define a learning point, the AAR leader must guide and focus the discussion. Bosley et al., Word, Downs et al., and SHERIKON stated that an efficient method of doing this was to ensure that the training objectives and conditions were clearly understood to serve as a framework for the discussion. Word and SHERIKON then recommend beginning the discussion with objective performance results such as the casualty exchange ratio or time required to complete a time sensitive task. The search for the cause of these effects will reveal the critical actions and events that must be investigated. A detailed cause and effect analysis will lead to the appropriate corrective action or training. Articulation of the corrective action or training plan is the point of the

discussion. The plan must address the purpose of training and link the original training objectives to the objectives of the corrective training.

The purpose of the AAR is to improve individual and collective performance; this never changes. The objectives of the AAR are to: 1) define the problems that will improve performance, 2) articulate the solution in relation to the training conditions experienced to increase learning, and 3) translate the solutions into future training objectives to reinforce learning. The AAR's purpose and objectives are different from the training purpose and objectives. However, problems and solutions identified in an AAR should support the purpose and objectives of training in that they concern behaviors that are associated with the specified training tasks. This will also limit the number of discussion points.

The procedure to achieve the AAR objectives must be rigidly enforced. The most efficient discussion focuses on what happened, why it happened, and how it can be done better. Discussion of other topics or events should not be permitted in order to conserve time and maintain the focus of the trainees' attention.

The AAR must allow the unit to clearly understand situational problems and realize practical solutions. Therefore, the conditions under which training is performed must be related to the behaviors executed to achieve specified goals. Once the factors that influence a weakness are identified and the cause and effect relationships established, solutions must be identified. The solution is "practical" only if the unit has the resources and capabilities necessary to implement it.

Additionally, unit strengths and weaknesses must be identified and assessed with respect to past performance/experience and Army performance standards and doctrine. The AAR leader must aid the trainees in the identification of strengths and weaknesses in an objective manner. Unless intimately familiar with the unit's past performance and a member of the unit's chain of command, he must avoid criticizing the group directly and leave the performance assessment to the unit and its leaders. This avoids the negativism associated with the judgments of an outsider to the trainee group.

The cause of the training weakness must be identified. Units perform poorly because they either lack the knowledge and/or skills (collective and individual) to perform the tasks; they do not practice the tasks and associated subtasks (they are "rusty"); they practice the tasks under unrealistic conditions and without specified standards for performance; or some combination of all three. The articulation of the root cause of poor performance will lead the participant trainees to the most effective corrective training solution. Hence, performance will be improved in an efficient manner.

Learning Reinforcement

The third element of an effective AAR is the reinforcement of lessons learned through rehearsal or, if at all possible, re-training. Research has shown that lessons reinforced by practice are understood more thoroughly, retained longer, and generalized to other situations more readily. (Anderson, 1993, and Meister, 1976) I am suggesting that the AAR not end with the development of the corrective training plan, but that it

should end when the corrective training is executed to the performance standards outlined by the leader. This allows the greatest opportunity for the unit to learn. Without this reinforcement, the unit does not maximize its performance improvement from the AAR.

Undoubtedly, the execution of the corrective training has the potential to extend the training exercise a great deal longer than originally planned if there are many and varied performance behaviors to correct. Therefore, the corrective training tasks to be executed should be limited to those that directly relate to the original training objectives. The rest should be planned for future training.

Another consideration for training plan execution is the fatigue level of the unit. Soldiers that have expended a great deal of energy during the training exercise and the AAR may not have much left for an intensive corrective training exercise. This highlights the need for the appropriate training strategy to be selected during discussion of how to do it better. Units have many strategies at their disposal. They range from a sand table exercise with only leaders to a fully attended MILES situational training exercise against an OPFOR. The important consideration when choosing a training strategy is to maximize the resources and personnel present at that point in time. It can take a considerable effort to re-coordinate and re-schedule training resources.

Time

Time influences the effectiveness of AARs in three ways: the timeliness of the AAR, timeliness of the retraining, and time length of the AAR. Subject matter

experience and studies have shown that the effectiveness of the feedback is inversely proportional to the length of time that transpires from the end of the training until the feedback is received. (Wortman, C. and Loftus, E., 1981, 201 through 205) The same time relationship holds true for retraining. Feedback has the most impact when cause and effect relationships and training conditions are still fresh in the trainees' minds. Hence, timeliness of the AAR is important to accurately diagnose performance and the timeliness of the retraining is important to practice corrective actions with respect to the diagnosis.

Logically, time has a third impact on effectiveness. As Word pointed out, the length of an AAR in time impacts on its effectiveness. The attention span of a human is limited, especially after rigorous training in a fatigued state. Soldiers, like students in a classroom, can only handle an average of three to four learning points before attentiveness dwindles. This means that there is only time for three to four problems to be identified, discussed, and solutions outlined with respect to future training.

A time efficient method of identifying a problem topic for discussion is to use the BDA results. The cause and effect relationships that produced training casualties or equipment losses are simple and efficacious discussion start points. Participants are naturally interested in discussing how and why each became or caused a casualty. Additionally, the quest to minimize casualties during an action is an obvious and important desire of the unit. Naturally, everyone wants to live. The accomplishment of the mission with the fewest losses in personnel and equipment is the basic purpose of Army training.

The length of the AAR in time will affect unit participation. AAR leaders must guard against letting discussions drag on. If participants seem disinterested or distracted, the discussion should be refocused, redirected, or terminated.

Foundations of Effectiveness in the Theory of Learning

The theories that support the proposed AAR system are derived from educational research and cognitive science. The intersection of these two separate and often parallel disciplines is the basis for the AAR. There are two questions that educational research revolves around: what curriculum content to teach and what strategy should be employed to relay this content to the student. (Williams, 1996a) Cognitive science, on the other hand, offers theories that explain how humans think and learn. Thus, the combination of these theories can explain the effectiveness and efficiency of learning for a specific teaching strategy and curriculum content. In other words, why a student learns more at a faster pace when given certain information in a specific manner.

Learning effectiveness and efficiency are the goals of any instruction. Given that, it is beneficial first to develop an understanding of these two terms. Learning effectiveness is the focus of knowledge engineering research that deals with how well a student learns the curriculum content. This is determined by testing the student's application of the acquired knowledge in some manner. Whether through oral and written examination or physical demonstration, the student is required to meet performance standards that are predetermined by the instructor. In this sense, the manner

in which the student learns is irrelevant unless it prevents him from mastering all of the knowledge. Thus, effectiveness relates to how much of the target knowledge units are learned.

Efficiency in learning is concerned with the length of time a student requires to learn a specific unit of knowledge. Instructional strategies seek to maximize the efficiency of learning by presenting and explaining the material in ways that the student quickly understands it. Most of the instructional research is on how to increase learning efficiency because knowledge engineering a curriculum is extraordinarily expensive in effort and funds. Notwithstanding the time and effort to engineer the curriculum, a reorganization of domain knowledge units requiring corresponding changes in teaching materials and instructor training (or retraining) is also monetarily expensive.

Cognitive science primarily seeks to explain how humans process information to accomplish tasks, solve problems, learn, and achieve other conscious actions or thoughts. This discipline is built on the premise that the human brain can be represented as an information-processing system. Basically, this system explains how sensory and motor organs receive and encode symbols from the environment and store them as memory. These memories hold interrelated symbol structures that are processed and output as sets of symbolic structures or encoded symbols sent back to the sensory and motor organs. (Williams, 1996a, Langley et al., 1987, and Card et al., 1983) In this manner, the system attempts to model the human cognition that results in perception and sensory inputs to prompt action.

The idea of the human information processor was developed by Allen Newell and Herbert Simon at Carnegie Mellon University in the 1960s and early 1970s. It gained popular support in the 1970s and has spawned a number of theories and models since. One of the most successful models of human cognition is John R. Anderson's Adaptive Control of Thought – Rational (ACT-R). (Anderson, 1993) This model explains the underlying learning processes of an effective AAR. However, a number of cognitive science terms must first be defined. Afterward, trainee learning is explained in terms of ACT-R. ACT-R is explained in detail in Appendix A, Theoretical Foundations.

Terms of Cognition

Meta-Cognitive Skill

In cognitive science, problem solving skill is also known as meta-cognitive skill. Specifically, problem solving is a collection of cognitive skills used to achieve the two stages of the problem solving process. These two stages are: 1) problem representation stage and 2) solution stage. (Simon & Newell, 1972) Cognitive research provides a convincing amount of evidence for the premise that the human problem solving process is a skill that can be learned and refined. (Chapman & Allen, 1994; Anderson, 1993; Newell, 1992; Lesgold et al., 1992; Shute and Glaser, 1990; and Langley et al., 1987)

Problem Space and Representation

A problem is represented by one or more *problem spaces*. The *problem space* is a cognitive term used to explain problem solving. Simon and Newell (1972) identify a number of invariant features that define problem spaces. All of these features are listed in Appendix A, Theoretical Foundations. The important feature is that the problem space is a finite set of knowledge that the problem solver associates with or recalls given a declarative fact. It is what the person knows and can consider. Therefore, the space is constantly changing and can be represented as a series of knowledge states where each state is generated from a finite (usually small) set of objects, properties, and environmental forces, and their interrelationships.

The knowledge states that make up the problem space are referred to as *problem states*. These problem states are initial, intermediate, and final situation problem representations. Thus, the problem space consists of an initial (understanding) representation of the problem, the final endstate (solution), and any number of iterative step states that connect the two (initial understanding → final solution). The problem state that represents the final solution is called the *goal* or *goal state*. (Langley et al., 1987, 9; Newell, 1992; Anderson, 1983; Card et al., 1983; and Simon & Newell, 1972, 811 and 812)

Each problem state employs one or more representation techniques to define itself. Langley et al. (1987) define the representation within the problem state as "a scheme for holding information in a memory, combined with processes for operating on

that information to access it, alter it, or draw inferences from it." (Langley et al., 1987, 315) The primary representation schemes recognized are list structures, sentential structures, and pictorial or imaginal structures. (Langley et al., 1987, 315 through 335) The bottom line is that humans use different representation schemes to represent a problem state within a given problem space. For a complete discussion of and evidence for problem spaces and representations see Langley et al. (1987) and Williams & Reynolds (1991).

Goals

The goal state of a problem space is always defined with respect to that problem space. In the same sense, a problem is always defined with respect to the environment it occurs, or is realized, in. Thus, the problem space provides the context for the goal state. Without this context, the goal state would have no meaning. The reason for this seemingly obvious statement is that, like many other tasks and experiences in life, where one ends up or finishes depends largely upon where or how the goal was defined. The presence/absence of a goal with respect to the problem state (or a task to be learned) determines the effectiveness and efficiency of problem solution (and learning of the task). (Newell, 1992; Williams & Reynolds, 1991; Anderson, 1986; and Jeffries et al., 1981)

In the above terms, learning can be defined as a problem solving process. Learning, as used in this thesis, is the acquisition of a new skill or knowledge that can

then be applied in a wide range of conditions and environments. Implied here is that the knowledge and skill of previous experience is retrieved for use in the acquisition process. Essentially, this process is problem solving. The initial state is defined by previous experience (what is already known). The goal state is the target skill or knowledge to be acquired. The intermediate states, between the initial and goal state, are the iterations of step states to get from the initial state to the goal.

What may not be apparent from the above definitions is that problem states can subdivide into multiple sub-problem states. Just as people consciously break problems into manageable components, so does the cognitive control decompose problem states. These definitions and their interactions basically subscribe to Newell's theory of problem solving called SOAR. (Newell, 1992) SOAR is a problem solving theory of cognition that explains acquisition of text editing skills that are represented with the GOMS (Goal-Operator-Method-Selection rule) knowledge representation technique. (Card et al., 1983, and Williams & Kotnour, 1993)

Compelling evidence for the importance of problem spaces in problem solving is presented in Langley, Simon, Bradshaw, and Zytkow (1987), Scientific Discovery: Computational Explorations of the Creative Processes. In their research, Langley et al. modeled a number of significant scientific discoveries with computer-based production systems. The production rules were based on the scientific method – the systematic assessment of a problem, followed by hypothesis formulation, data collection, and hypothesis testing. Langley et al.'s research centered on the hypothesis that "scientific

discovery can be explained as a form of problem solving; that its basic processes are 'normal' problem-solving processes, adapted to the particular characteristics of the domain of discovery." (Langley et al., 1987, 338) The following is a list of discoveries that their artificial intelligence (AI)-based scientists rediscovered: Planck's discovery of the law of blackbody radiation and its consequences with respect to quantum action; Newton's discovery of the law of universal gravitation; Kepler's third law of planetary motion; Boyle's Law; Galileo's law of uniform acceleration; Ohm's Law; Snell's law of refraction; Black's specific-heat law, and conservation of momentum; Joule's law of energy conservation; Dalton's atomic theory; and the qualitative laws of acids and bases (that preceded the and prompted the later discovery of their empirical relationships). This collection of discoveries can be categorized as finding quantitative laws, generating qualitative laws, inferring the components of substances, and formulating structural models.

Besides proving that the general approach of scientific inquiry applies across a broad spectrum of disciplines, Langley et al. found something more profound. Each of these discoveries was based not on any particular genius or magical "flash of insight," but on how one defined the problem space. (Langley et al., 1987, 312, 328, and 339) Specifically, they demonstrated that the generation of research problems is a problem-solving process that can be formalized and approached in the same manner as other problem-solving processes. Hence, the discovery of the correct problem space is the real

accomplishment and it is this problem definition that is the most important factor in a learning experience.

As a leader in cognitive science, John Anderson's work is important in this context because he conclusively showed that cognitive skills are realized by production rules. Thus, the foundation of Langley et al.'s AI programs is validated by Anderson (1993). Anderson's ACT-R is the most successful model at describing human knowledge acquisition, performance, and transfer to date.

Learning and ACT-R Theory

In Intelligent Simulation Training Systems Design, Kent E. Williams (1996a) reviews current cognitive theories of knowledge representation, knowledge acquisition, and problem solving. Theories of cognition attempt to explain how humans *process* and *recall* information to acquire skill. Problem solving, or meta-cognitive skill, is how humans *use* the information processed or recalled. These cognitive theories describe the underlying mechanism of the meta-cognitive processes associated with learning.

Again, ACT-R is a very successful model at describing knowledge acquisition, performance, and transfer in a knowledge-based (task based) environment. (Williams, 1996a) Anderson explains ACT-R and outlines its success in Rules of the Mind, (1993). He posits that the success of modeling human learning and performance with ACT-R validates its production system structure. With this conclusion, ACT-R is offered as proof *that human cognitive skills are realized by production rules*. (Anderson, 1993) An

earlier version of ACT-R, ACT*, was independently validated and verified as an individual basis for learning by Bonarini & Filippi (1993) and in a classroom setting with strong learning effects by Schofield et al. (1990). Another conclusive and comprehensive experiment that verifies and validates Anderson's theory with respect to problem solving is Swan & Black (1993). This research tested meta-cognitive skill improvement as a result of knowledge-based declarative instruction/tutoring and procedural practice.

Production rules (or productions) are *condition–action* pairs or if–then rules. (Anderson, 1993, 4 and 5) The *condition* side specifies the circumstances under which the action side will apply. The *action* side specifies what to do if the circumstances are satisfied. These productions form the basic units of skill. In other words, productions are what a student learns. Furthermore, the analysis to identify the production rules in a knowledge domain and then the teaching of those rules leads to efficient learning. (Anderson, 1993; Williams, 1996a; Williams & Reynolds, 1991; and Kieras & Bovair, 1986) The identification of critical knowledge units is the purpose of knowledge engineering.

More specifically, ACT-R is a computational model of productions with the premise that learning is based upon what is already known – prior experience. This experience is stored in procedural memory and consists of the production rules with similar goals and/or conditions. (Anderson, 1993) With more elaboration and practice, these productions become situation specific allowing the experience to be situation-based. The subject learns by iteratively applying that experience to a given problem.

ACT-R's implications for skill acquisition are summarized below. These derive directly from the argument *that human cognitive skills are realized by production rules.*

- The knowledge underlying a skill begins in an initial declarative form (an elaborated example), which must be interpreted (problem solved by analogy) to produce performance.
- As a function of its interpretive execution, this skill becomes compiled into production-rule form.
- With practice, individual production rules acquire strength and become more attuned to the circumstances in which they apply; they become situation based.
- Learning complex skills can be decomposed into the learning functions associated with individual production rules. (Anderson et al., 1993, 143)

Given that production units are the basic units of skill, performing a detailed cognitive task analysis with respect to productions can improve performance. More efficient learning is achieved by using this analysis (of the production units) to specifically incorporate the identified knowledge chunks into the curriculum. (Anderson, 1993; Williams, 1996a; and Williams & Reynolds, 1991) Thus, the question arises of why task analyses, in production level detail, have not been employed in training systems? The short answer to this question is that the task analysis process is an

extremely expensive venture in both time and resources. (Williams, 1996a, Williams, 1995, and Chapman & Allen, 1994)

Cognitive and meta-cognitive research strongly supports the focusing of an AAR discussion on a performance problem-solution to learn. (Roschelle & Teasley, 1995; Anderson, 1993; Swan & Black, 1993; Newell, 1992; Williams & Reynolds, 1991; and Langley et al., 1987) The goal of the discussion is to develop a solution of corrective actions. It is a problem solving discussion.

The "what happened" and "why it happened" specified in doctrinal guidance are only important in terms of diagnosing performance to identify the needed corrective behaviors. The learning in terms of improved performance derives directly from strengthening the productions that define the corrective action. It is the corrective action that produces the desired effect of improving performance. (Williams & Reynolds, 1991, and Black et al., 1987)

The knowledge that underlies a skill begins as an elaborated example. (Anderson, 1993) Verbal elaboration allows the new knowledge to be associated with past experience in the proper context. In terms of military performance, this elaboration allows an individual to associate a corrective action (behavior) with a proper interpretation of perceptual cues. In other words, if (cues) a squad occupies a support by fire position and cannot suppress all of the enemy positions, then (corrective action) the squad must reposition to obtain observation of all enemy positions. Here the members of the squad must be able to articulate *what* perceptual cues will indicate that they cannot

suppress all of the enemy positions. In this example, the first indicators will most likely be one or both of the squad receiving effective fire/casualties and/or a message that their fires are ineffective. The point is if they can articulate the conditions and actions, then they will be able to perform the corrective action upon recognizing the situation. The trainees' ability to proceduralize the learning point (conditions-corrective action) is a function of their interpretive execution of that specific task.

The next step is to physically practice the corrective action before the memory of the declarative elaboration decays. As Anderson (1993) shows, sooner is better. He empirically demonstrated that a knowledge unit's retention and recall for use are a function of frequency of use and time since last used. Moreover, retention and recall can be improved as a power function of trials (number of times of repeated use), but will decay as a function of delay. Thus, efficient learning calls for the significant behaviors to be identified and reinforced immediately after the training experience. If a specific performance outcome is desired, then the modification of behaviors to achieve it must also be immediate. Practice until one gets it right.

The timely execution of corrective actions to modify behavior is critical to learning. A unit must elaborate amongst themselves what tasks will be performed, given a specific set of conditions, to achieve the designated goal. The elaboration allows individuals to associate (understand) the corrective actions with past experience and acquire the same behaviors to achieve the goal. The next step is physical practice to

reinforce the newly formed productions of common understanding. Hence, learning reinforcement amounts to repetitive, mental and physical practice.

Anderson made one other significant finding relevant to AARs and learning; the learning process was made more efficient by instructor guidance. (Anderson, 1993, 159) Students without the benefit of a tutor took the longest to learn. Those that did learn "on their own" did not know the subject any better than those who received direction and guidance, they simply took longer. Thus, there is no benefit gained from learning a number of wrong ways before discovering a right way. This is counterintuitive to most teachers/people who believe that there is some benefit derived from knowing why things are wrong or what will not work when mastering a subject domain. Anderson's finding does not totally reject this paradigm. He found that knowing the correct answer first led to a quicker discovery and understanding of the relationships between correct and incorrect solutions. Again, the strongest independent confirmation of Anderson's finding is Swan & Black (1993).

The finding that guided discovery is more efficient justifies the AAR leader's role. This justification assumes that the AAR leader possesses the knowledge (experience) to guide the trainee discussion to a correct solution of performance problems. Here lies an inherent problem of a novice leading an AAR. If the AAR leader is not familiar enough with doctrine to apply it to a tactical performance problem, learning efficiency is decreased as he and the trainees stumble through a number of incorrect solutions. In this case, the AAR participants' situation is similar to that of a

team of scientists endeavoring to discover the relationships that will describe a particular phenomenon. The situation calls for systematic, goal oriented search of the problem space.

Conclusion

The AAR is a critical part of the Army training system. It evolved as the Army's ability to simulate combat conditions in training improved. The AAR was fully defined and disseminated as doctrine with the establishment of the CTCs – NTC, JRTC, and CMTC. The CTCs have set the example in how to train and implement the AAR as a vehicle for performance feedback. The exact form of this example is explored in Chapter III.

The effectiveness of the AAR is derived from four elements: discussion participation, discussion focus, timeliness, and learning reinforcement. The interdependence of these elements are just as important as an element is by itself. The first is the unit's participation in a discussion to discover and define performance problems, develop solutions, and formulate corrective action plans. This is critical because it allows the unit, not the AAR leader or outside observer, to articulate what happened, why, and how to fix it. Hence, the unit realizes the problem, takes ownership of the solution, and learns in the process. Learning is facilitated by discussion participation which allows unit members to explain the relationships that affect performance to one another in their own terms, at their own level of understanding.

Second, the AAR should be a professional and dynamic discussion focused on solving performance problems. The trainees learn by verbally elaborating the problem solution in terms of their past experience. Specifically, the focus of the discussion is on the elaboration of the relationship between past experience and the solution. Focusing on one problem at a time, the end state of the AAR should be that the unit has collaborated to achieve a clear understanding of:

1. *What* happened during the training exercise;
2. The conditions and behaviors that caused measured outcomes (results);
3. *How* the behaviors or conditions could be modified to achieve the desired performance outcomes; and
4. A training plan to sustain successful performance and correct deficient performance.

The training plan should include the tasks to be trained, constraining and limiting conditions to be trained under, and standards of performance tied to the purpose and objectives of the training. Furthermore, the unit should perceive this plan as its own creation in accordance with its needs and not dictated by superior officers, the AAR leader, or a computer based system.

Third, the AAR must be conducted within a short time period of the training event so that the learning will have significance. This will help the unit to efficiently reinforce successful performance and correct weak performance. Additionally, the AAR must be conducted within a unit's fatigue capacity. It must be of a reasonable length of time that

does not exceed the unit's capability to concentrate on problem solving. Time also affects the fourth element of effectiveness, learning reinforcement.

The AAR must allow for the timely practice of specified solutions at the earliest possible opportunity. Most importantly, the solutions are associated with past experience by mental rehearsal as well as physical performance. The sooner that the elaborated actions can be physically performed (practiced), the stronger the solution representations will be in the trainees' minds. The timely execution of this corrective training is critical to the reinforcement of learning. If a unit does not perform the corrective or reinforcing training as it plans, then the learning points and previous training are relegated to unimportance and have been a waste of time.

Chapter III examines the CTC AAR system and its implementation with respect to effectiveness and simulation training system support components.

CHAPTER III

CTC AFTER ACTION REVIEWS

"The truth is sought, regardless of whether pleasant or unpleasant."
— LTG Leslie J. McNair

AARs are the US Army's mechanism for individual and unit performance feedback in training and combat. (DA, FM 25-101, 1990, and TC 25-20, 1993) As such, the CTCs have set the example in the conduct of AARs and realistic training for the rest of the Army and the training system research and development community. For this research, the scope of the Army's training domain includes combat and combat support units who conduct training in live, virtual, and constructive simulation environments. These units are not restricted to one training environment but may also train in a combination of environments. Whatever the setting, leaders design and execute battle focused training as realistically as possible so that performance feedback is meaningful. The AAR is the vehicle for this feedback in all types of training. (DA, FM 25-101, 1990) In this respect, it is beneficial to review what the AAR components are at the CTCs and how this example is applied to small unit training simulation systems.

Currently, AARs come in a number of shapes and sizes for training simulation systems. The Simulation, Training, and Instrumentation Command (STRICOM) and commercial contractors are developing a number of simulation training systems to meet training needs. To a varying degree, each has its own version of an AAR "system." Small unit simulation training systems are no different. The Simulation Network (SIMNET) was purposefully built without an AAR system because the requirements had never been defined. (Meliza, L., 1996, 3) The Close Combat Tactical Trainer (CCTT) will replace SIMNET as a virtual simulation trainer for the platoon with the additional capability to train company teams. Its AAR system requirements are still being developed. (SHERIKON, February 1996, and STRICOM, July 1996)

Since CTC AARs serve as the example for Army combat training, the purpose of this chapter is to demonstrate what they consist of in light of the elements of effectiveness in the previous chapter. Once the example is clear, current small unit simulation and training systems will be surveyed to identify their components.

This chapter and its conclusions are based upon two assumptions. The first is that US Army combat units train IAW doctrine and seek to conduct AARs IAW this doctrine. Given that officers and noncommissioned officers receive very little formal training on how to conduct an AAR (personal experience), each learns by the example of others. It follows then, that the principal AAR example is established at the CTCs. A number of active duty US Army officers confirmed that most division level AAR guidance is a paraphrase of the CTC AAR guidance. (Personal communication with: Bedell, B., 30

October 1996, Lartigue, L., 2 November 1996, Lipinski, M., 2 November 1996, Lusher, R., 30 October 1996, and McCarthy, J., 30 October 1996) It also follows that the CTC AAR models define the Army training community's expectations of what an AAR should be.

The second assumption is that AAR systems built for simulation training systems are designed to meet the requirements of Army doctrine and the training user's needs. Combined with the first assumption, this implies that since the user's needs and expectations are defined by the CTC AAR example, that example also serves as a model for simulation training system AARs. This is supported by the fact that STRICOM and AAR system contractors constantly reference the CTC AARs in written and verbal presentations. (US ARI, 1997, STRICOM, 1996f, BCTD, 1996b, STRICOM et al., 1996, and STRICOM, 1994)

CTC AARs

Both the JRTC and the NTC produce AAR guidance on videotape for the OCs who are designated to lead the AAR. Each tape is intended for use with FM 25-101 and TC 25-20 and provides the AAR leader with the techniques and procedures for preparing and conducting an AAR. (JRTC/BDM, 1993, NTC, 1994, and NTC/BDM, 1992) AARs at both CTCs are led by a senior OC who has a certain amount of latitude in interpretation of doctrine and how guidance is implemented. However, JRTC and NTC differ on how they present the material and the specific points emphasized in the AAR.

JRTC

The JRTC AAR guidance states that the "key to an effective AAR is the OC," the AAR leader. (JRTC/BDM, 1993) Although the guidance does not specifically define what makes an AAR effective, it implies that effectiveness can be achieved by the following guidance of what an AAR is:

- A professional discussion of an event or task that focuses on performance standards.
- Allows soldiers to evaluate for themselves what happened and why.
- Concentrates on how to sustain strengths and improve on weaknesses.
- Is a tool leaders can use to extract the maximum benefit from experiences of training.
- It is important to include all members of the unit in the AAR.

(JRTC/BDM, 1993)

These support the elements of effectiveness defined at the end of the second chapter – participation and the discussion to clearly define weaknesses/strengths and corrective/sustainment action.

The preparation guidance focuses on the OC identifying two to four key issues to be covered in the AAR. These issues should be related to the critical actions and their effects that occurred during training. The guidance states that the discussion of how to fix these issues is the "heart of the AAR." To achieve this, the AAR time is broken down as follows: 25% of the time spent on what happened, 25% spent on why it happened, and

50% spent on how to do it better. (JRTC/BDM, 1993) The JRTC suggests that a specific AAR format (Table 3.1, JRTC AAR Format) be used to achieve this guidance.

Table 3.1, JRTC AAR Format

1. Introduction. Specify purpose and length of the AAR. Introduce the key issues.

2. Review the mission or task performed and the associated doctrinal training standards.

3. The unit commander explains his mission and plan.

4. The OPFOR representative explains his mission, plan, and execution of the plan. The OPFOR representative then presents observations of the unit's performance.

5. What happened? The OC summarizes the key events and their results in terms of BDA.

6. Discussion of 2-4 key issues.
   a) Select the key issues that affected the battle outcome the most.
   b) Emphasize why it happened and how to do it better.
   c) Link weaknesses to the plan, preparation, and execution phases of the training for easy transition into how to do it better.
   d) The OC can organize the discussion by battlefield operating system (BOS).

7. Senior noncommissioned officer OC presents observations of individual task performance.

8. Key leader self-assessment: allow unit to input what they will fix and sustain; record and ensure individuals sign up to fix/sustain items or behaviors that they control; force the unit to explain how they plan to fix the shortcomings or weaknesses; and finish with a clear bottom line.

9. Summarize training standards and key lessons learned.

10. Cover safety issues and any fratricide.

(JRTC/BDM, 1993)

JRTC guidance places the onus of selecting the discussion issues on the OC. The OC selects the event results or performance outcomes that correspond to a training standard, specified in the doctrinal manuals, as the issues. This allows the discussion of strengths and weaknesses to be founded on objective results that are not questionable. It also is an efficient method to identify discussion topics when the trainees are hesitant to do so.

The trainees receive performance feedback from three different people. The AAR leader OC, the OPFOR representative, and the senior noncommissioned officer OC. This feedback is presented via terrain models, large maps with operational graphics, overhead projectors, flip charts, video and audio recordings, and computers. The guidance specifically states that the use of these training/visual aids "must facilitate discussion...and should be limited to those that will assist in making the point or clarifying the situation. Too many training aids will detract from the AAR and confuse participants." (JRTC/BDM, 1993)

Although the OPFOR representative is initially involved, the free-play training exercise considerations prevent him from staying for the entire AAR. However, the trainees are allowed to question and discuss issues with him before he leaves. (JRTC/BDM, 1993) It is important that the OC brief the OPFOR representative on the selected key issues so that he can present the corresponding enemy actions. The OPFOR presentation can also lead to discussion of key issues that the participants identify. If this happens, the OC or the unit must prioritize the issues to discuss as there will not be

enough time to cover them all. The guidance for AAR length is one hour for platoon and two hours for company level AARs. (JRTC/BDM, 1993) A mission of two to three days is the normal period of training that is covered by the AAR at JRTC.

The OC facilitates the key leader self-assessment by prompting individuals to assume responsibility for implementing corrective behavior for weaknesses or reinforcing behavior for strengths. It is important that the OC ensures the soldiers only assume responsibility for those issues that they can affect. (JRTC/BDM, 1993) In this manner, responsibility for both short term and long term solutions is fixed.

The AAR is concluded with safety and fratricide issues that occurred during the training exercise. (JRTC/BDM, 1993) This is a reinforcement of the Army's policy to train safely and keep safety consideration at the forefront of leaders' minds. (DA, FM 25-100, 1988b, 1-3 and 4-3)

NTC

To focus the OC, the NTC AAR guidance defines an AAR as "a structured review process that allows participants to discover for themselves what happened, why it happened, and how it can be done better." (NTC/BDM, 1992) The NTC guidance states that there are five standards that define a successful AAR.

1. Allow the unit to self discover.
2. Establish cause and effect relationships.

3. Facilitate problem solving.

4. Base the AAR on doctrine, tactics, techniques, and procedures.

5. Always foster continuous improvement by the unit. (NTC, 1994, and NTC/BDM, 1992)

To achieve these standards, the OC may format the AAR to cover key issues, the Battlefield Operating System (BOS), a chronological execution of events, or a teaching/lecture of learning points. The OC chooses the format that best fits the AAR issues and causes the unit to solve the problem. The guidance recommends either selecting key issues or using the BOS to identify strengths and weaknesses. It recommends against using the chronological review of events since issues are not highlighted and this method uses a lot of time. The teaching/lecture method is to be used only if the unit is significantly below Army performance standards and is incapable of self criticism. (NTC/BDM, 1992)

The NTC guidance also specifies that the plan/prepare/execute structure be applied to the AAR discussion. This structure allows units to categorize the discussion so that performance tasks can be identified as the cause of specified effects. (NTC, 1994, and NTC/BDM, 1992) Hence, the question of why an event occurred can be easily tied to the good/poor performance of an individual or collective training task. This also allows the unit to easily prescribe training to correct or reinforce performance. The guidance emphasizes that the AAR is not a critique and should focus on meeting

doctrinal performance standards. (NTC, 1994, and NTC/BDM, 1992) Table 3.2 lists other "do's and don'ts" for the NTC OC.

Table 3.2, NTC AAR Do's and Don'ts

Do	Don't
Establish an agenda	Talk down to the unit
Encourage note taking	Argue with the unit
Record key issues/solutions	Do all the talking
Be flexible	Allow MILES sniveling
Summarize the AAR	Use subjective assessments of unit actions
Present a professional appearance	

(NTC/BDM, 1992)

The NTC guidance emphasizes the use of a terrain model as critical to the AAR. The terrain model combined with concept sketches of events or actions enables the trainees to clearly visualize what happened and why. (NTC/BDM, 1992) The trainees are also better able to collectively identify cause and effect relationships with a common vision of the battlefield. The other aids that are emphasized for platoon and company level AARs are photographs and large scale maps overlaid with operational graphics. (NTC, 1994)

In actuality, recent experience at the NTC shows that photographs are unavailable at the small unit level. Platoon AARs are held in the vicinity of the battlefield within 30 minutes of the exercise's end. Company AARs are also held in the field two hours after the exercise's end. The photographic aids are unavailable for these AARs because photographs of the action cannot reasonably be taken, developed, and delivered in time. The terrain model, preprinted text slides, dry-erase boards, and sketch pads are the primary AAR aids used. (Lartigue, L., personal communication, 2 November 1996, and Lipinski, M., personal communication, 2 November 1996)

CTC AAR System

A couple of observations can be made from the JRTC and NTC AAR guidance tapes. First and foremost, the style and effectiveness of the AAR is a function of the AAR leader. The AAR leader's skill is critical in identifying the potential discussion issues and then deciding what format is best for drawing out those issues from a particular group of trainees. The AAR leader must tailor the AAR to the needs of the discussion group. As pointed out at the end of Chapter II, this is dependent upon the collective skill level of the unit.

The second observation is that three of the determinants of an effective AAR are verified by the guidance. Participation, discussion focus, time limits, and problems and solutions are all specifically identified as important. Learning reinforcement is not addressed.

Given the AAR guidance of the CTCs and the doctrinal references, the conduct of the CTC AAR can be represented as a system. (Figure 3.1, Conceptual CTC AAR System, and Figure 3.2, CTC AAR Components) This is only a part of the AAR process. The entire AAR process parallels the training management cycle beginning with defining the data collection and feedback requirements from the training objectives and purpose.

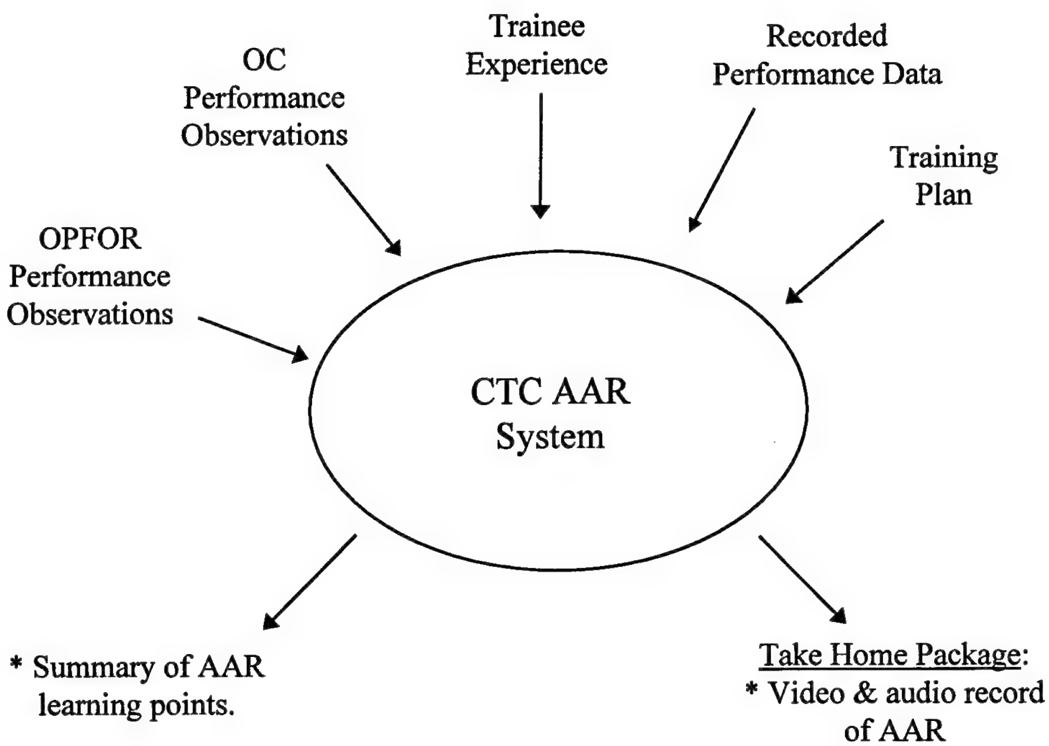

Figure 3.1, Conceptual CTC AAR System

The inputs into the AAR are collected or developed during training exercise execution and AAR preparation. At the CTCs, performance data is primarily collected

from the OC team's and the OPFOR's performance observations. These observations are hand recorded by the OC or an assistant.

At the CTCs, the trainer is the Division Commander of the brigade participating in the training. For the exercise, the Division Commander determines the training objectives, missions to be executed, and conditions of the battlefield. These are the same conditions that are reviewed in the AAR to help determine what happened, why it happened, and how to do it better. The Operations Group of the CTC is responsible for implementing the training plan, controlling the exercise, and providing feedback at each unit level.

The fourth input to the system is recorded performance data. Vehicles and key personnel are instrumented so that position and movement can be tracked and recorded throughout the exercise. Additionally, the radio transmissions of key leaders are recorded and time stamped to aid in determining what happened during the exercise. Although these are not available during the AAR, what was recorded can be relayed to the OC via radio communications. Additionally, the MILES kill codes are recorded by each weapon system and are available to the OC team.

The last input is the training experience of the unit. The unit experience is what a unit performs during training. This experience is formed with incomplete knowledge of the situation and, as a result, misperceptions. Notwithstanding, this is what the trainees *know* when they come into the AAR. This information is verbally presented by the trainees to achieve the AAR objectives.

The outputs of the CTC AAR process are a summation of the learning points from the AAR and a videotaped record of the AAR itself. The OC that leads the AAR is responsible for summarizing the learning points. The trainees write these points in their notes or may obtain a text copy from the OC. The AAR is recorded on videotape for the unit. This, along with a written summary of the OC team's observations, makes up the unit's take home package. The OPFOR do not input observations directly into the take home package. However, the OC team may include those observations in the written product.

The physical and conceptual components that interact during the AAR are shown in Figure 3.2, CTC AAR Components. The OC leading the AAR also controls the AAR components. He controls what information is presented when and on which medium. CTC mediums or training aids include terrain models, video and audio display systems, overhead projectors, chalkboard or sketch pad, pre-made charts with textual or graphical data, and computer display systems. The OC selects the medium that can best support the learning point.

The trainees receive feedback from the AAR leader, OPFOR, and the presentation mediums. The communication between the trainees and the AAR leader/OPFOR is the discussion between them. This discussion takes the form of questions, answers, and comments. What is not shown is the communication that occurs amongst the trainees. The CTC AAR guidance does not address how to prompt this discussion and seems to suggest that it occurs spontaneously.

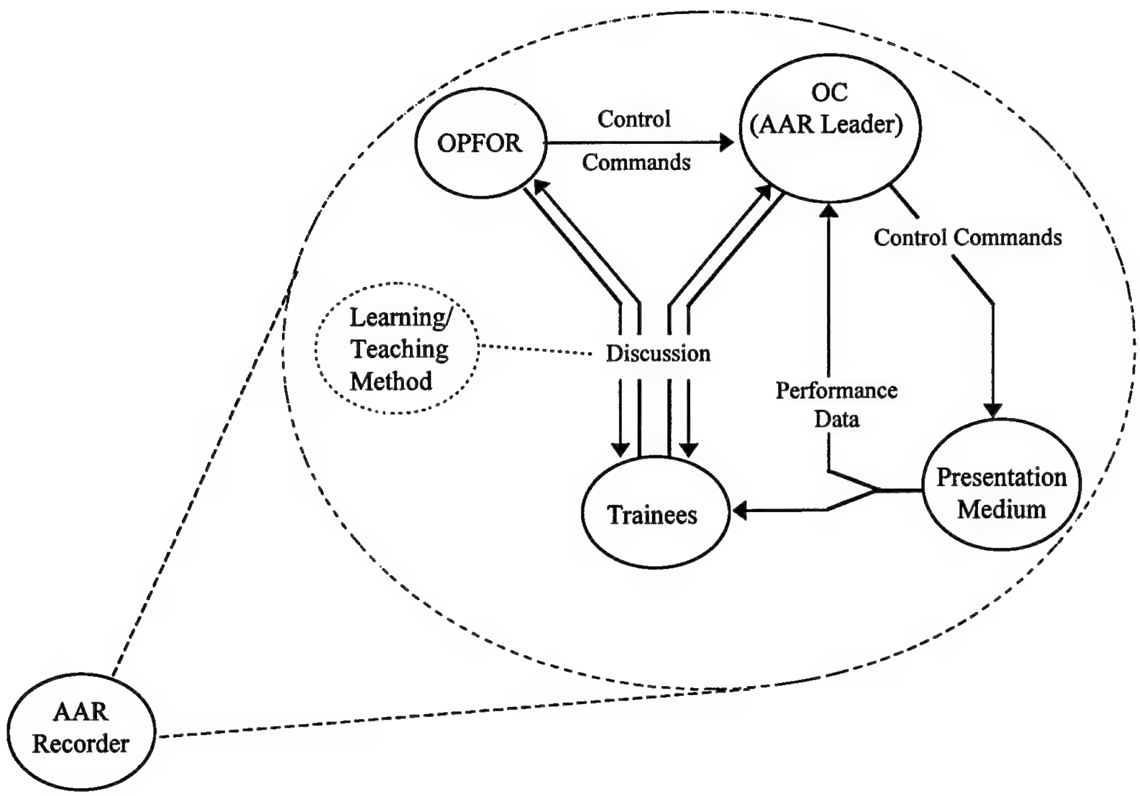

Figure 3.2, CTC AAR Components

The OPFOR are depicted interacting with the trainees. In fact, this occurs only for a small portion of the AAR. Because of training exercise considerations, the OPFOR representative returns to his unit immediately after he presents his observations and answers any questions the trainees may have. Usually, this lasts for approximately 10 minutes. (AAR tapes and personal experience)

The AAR recorder is responsible for the audio and visual record of the AAR. Normally, one cameraman films the AAR from a stationary point. He is specifically responsible for capturing the key points and the discussion during the AAR.

The learning/teaching method component is addressed by the NTC AAR guidance and accounts for how the AAR is conducted/run. The NTC guidance identified the teaching/lecture method as appropriate for some situations. This is certainly one end of the learning/teaching method spectrum. For the CTCs, the other end of the spectrum is defined by a discussion in which the AAR leader and trainees participate. The amount and distribution of the participation serve to define the learning/teaching method states between the lecture and a fully participatory AAR.

Small Unit Simulation Training Systems

Currently, the Army's small unit simulation training systems are SIMNET and CCTT. Both train platoon and company collective tasks in a virtual environment. SIMNET is the legacy system and CCTT, its replacement, is the first of a number of virtual training systems that will form the Combined Arms Tactical Trainer (CATT). In completion, the CATT will consist of the: CCTT for mechanized infantry, armor, and cavalry units; Aviation Combined Arms Tactical Trainer (AVCATT) for Army aviation units; Fire Support Combined Arms Tactical Trainer (FSCATT) for field artillery and mortar units; Air Defense Combined Arms Tactical Trainer (ADCATT) for air defense units; and Engineer Combined Arms Tactical Trainer (ENCATT) for engineer units.

(STRICOM, 27 Aug 1996a) Each training system will be Distributed Interactive Simulation (DIS) compliant and consist of networked, high fidelity, manned simulators, Semi-Automated Forces (SAF), support workstations, computer networks and protocols, and an AAR system. (STRICOM, 27 Aug 1996b)

AAR Systems in Training Simulations

Larry Meliza's research report, Standardizing Army After Action Review Systems (1996a), is the most complete and thorough source reviewing Army AAR systems and efforts for small unit training systems to date. Meliza conducted the research to support development of the needs and capabilities for the Standard Army After Action Review System (STAARS). To complete this research, he reviewed the relevant literature, published and unpublished findings of three Army-wide AAR conferences, and examined two ongoing AAR system development efforts in relation to a legacy AAR system. The Army Training and Analysis Feedback System (ATAFS) and the Simulation Training Integrated Performance Evaluation System (STRIPES) were compared to the development of the Unit Performance Assessment System (UPAS) to clarify the needed capabilities of STAARS. Many of Meliza's findings were used by the National Simulation Center as capability specifications and rationale for the STAARS Operational Requirements Document (ORD). (Meliza, 1996a, viii)

The UPAS, ATAFS, STRIPES, the CCTT AAR system, and STAARS are recounted in detail in Appendix C, Current AAR Systems in Training Simulations. The

review of Meliza's research reveals that these systems are primarily concerned with reducing the workload associated with preparing the AAR and formatting the information products that result from the preparation. In other words, these systems focus on automating data collection, compilation, and display to reduce the amount of time it takes a trainer/AAR leader to prepare an AAR for presentation. In this sense, these AAR systems are not specifically designed to improve the AAR's effectiveness as much as they are to ensure its timeliness.

This is not to say that displaying information effectively is/was not a concern during AAR system development. The initial UPAS development effort focused on providing information displays that made it easier for trainees to grasp what happened during a training exercise. (Meliza et al., 1992b) This resulted in the five format displays incorporated into ATAFS.

The need for preparation efficiency is driven by two reasons. As Meliza points out, lower echelon AARs precede higher echelon AARs so that the results of the first can be used as input for the second. Thus, to start higher echelon AARs in a timely manner, lower level AARs must be completed as soon as possible. The Mounted Warfare Training Simulation Center at FT Knox, KY tries to begin platoon AARs 10 minutes after the end of a training exercise. (Meliza, 1996a, 27) Another reason to rush preparation is that units may need to conduct subsequent exercises on the trainer and therefore need the AAR system to collect data for their exercise. Currently, none of the

AAR systems have the requirement nor capability to display a presentation for a previous exercise while collecting data from a separate running exercise.

None of the systems seek to promote or improve trainee participation beyond information presentation. However, well designed data displays will aid units in determining what is critical and what happened. The more quickly ground truth can be represented, the faster the unit can focus on why it happened and how to do it better. Except for STAARS, none of the systems propose tools to aid in determining how to perform a task better. STAARS requires the capability to: "translate lessons learned from the CALL [Center for Army Lessons Learned], Battle Command Battle Lab experiments, CTC rotations, and other sources into leader development and collective training concepts, methods and strategies and revised doctrine and/or tactics, techniques, and procedures." (BCTD, 1996a, para 3.a.2.a.6) Although this capability is not identified for use during the AAR, it is conceivable that if information is collected, it could be stored and updated for use in the AAR also.

The retraining of specific tasks is also not considered essential to an AAR system capability. Currently, none of the systems require this. This is understandable given that the popular interpretation of the training model paradigm concludes the cycle with the AAR. As stated before, this must change in order to reinforce the learning that occurs during the AAR.

The bottom line of these simulation AAR subsystems is that they support the implementation of the CTC AAR system and will reinforce whatever strengths and

weaknesses that approach has. These subsystems contribute directly to the AARs effectiveness by reducing the required preparation time and collecting a wide variety of objective performance data. Thus, there are two apparent results. First, the delay between the end of the training exercise and the start of the AAR is minimized. And second, performance (what happened) can be more accurately and objectively described.

Survey

Purpose

Given that the CTC AARs are what the training community and research and development communities are trying to model, how effective are they with respect to discussion participation and focus? What factors influenced the measures of effectiveness most? The purpose of the survey of 17 platoon and company AARs from the JRTC and the NTC is to provide indications of the answers to these questions. A result of this research is the development of definitions and procedures that can be used to assess the effectiveness of an AAR. Only platoon and company level AARs were used because the focus of this thesis is at the small unit, below battalion level.

Measuring Effectiveness

The measures of effectiveness used are those that were argued in Chapter II and supported by CTC guidance – trainee discussion participation, discussion focus on

learning points, and time length of AAR. Since follow-on training is not recorded and there is no indication of when the training exercise ended, the retraining and timeliness measures of effectiveness cannot be measured by the AAR tape alone. In any case, immediate retraining is not permitted at the CTCs because of overall scenario time constraints. These same time constraints drive the scheduling of all AARs and the OCs strictly adhere to this schedule.[7] Hence, the timeliness of the AAR is reasonably constant. The dependent variables that combine to describe each measure of effectiveness are discussed below.

Discussion Participation Dependent Variables

Trainee, OPFOR, and AAR leader participation allow multiple viewpoints to be considered while solving problems as well as the clear and complete articulation of what happened and why during the exercise. To collect data on participation, the following were counted:

- The number of questions and comments (utterances) per individual during the AAR;
- The number of trainees present at the AAR;
- The number of issues identified by the trainees vs. the AAR leader;
- The number of training solutions identified by the trainees vs. the AAR leader;

[7] AAR schedule: JRTC – platoon AARs are conducted 1 or 2 hours after the end of the exercise (ENDEX), and company AARs are conducted 4 hours after ENDEX; NTC – platoon AARs are conducted 45 minutes after the end of the exercise, and company AARs are conducted 90 minutes after ENDEX.

- Occurrence of discussion amongst the unit without AAR leader intervention.

The number of utterances per individual and the total number of trainees were the same data collected by Downs et al. (1987). Displayed as ratios of unit to AAR leader utterances, these will indicate a relative level and distribution of participation amongst the AARs surveyed. Tracking the number of questions and comments will give some indication of active participation by the trainees and the use of the questioning technique by the AAR leaders. A ratio of unit comments to AAR leader questions will indicate how many units made comments beyond the question responses to the AAR leader.

For this research, an issue is defined as a subject or point for discussion. The issue can be specific or general but must pertain to the unit's performance. Thus, a specific task such as *control movement of a platoon* or a general subject such as *planning* are counted as issues. The term "key issues" is used extensively in AARs throughout the Army and is understood to be synonymous with the points that will be discussed. Either the AAR leader, unit commander, or AAR participants can decide what issues are important enough to spend discussion time on.

The questions counted were interrogative statements or fragments that were intended for response. Rhetorical questions were counted as comments. The comments counted were sentences, phrases, or utterances in response to a question or another comment. Rephrased questions or comments were counted individually so that a posed question and the re-worded elaboration to explain the question count as two or three utterances. Repeated questions or comments were not counted separately unless they

were uttered at least five seconds apart. This collection constraint was implemented in an attempt to discount a high count of utterances from an individual who has a habit of immediately, and unnecessarily, repeating himself.

Identifying who submits problems and solutions for discussion was also tracked. This indicates how successful the AAR leader is at drawing learning points (discussed below) out of the unit. Basically, this is a part of guiding the discussion. The assumption is that units will discuss the problems that they identify more readily than those that are dictated to them by the AAR leader.

Discussion Focus Dependent Variables

As outlined in Chapter II, the complete learning point (problem space) consists of a clearly defined issue and a practical solution. A clear issue in Army training terms is the identification of the doctrinal training task that was/was not performed IAW doctrinal performance standards. The specific performance measures that define the desired outcome must be identified. Otherwise, it will not be clear what portion of task performance must be improved. An example of this could be identifying Perform Tactical Road March (DA, ARTEP 7-8-MTP, 1994, 5-82 to 5-84) as a problem issue. Without further explanation of the five task standards or seven associated subtask standards, there is no way to tell what was specifically wrong with the collective performance of this task. To clarify the issue, the problem must be articulated in the following terms: task standard #4 – "the main body was not surprised by the enemy" was

failed because subtask #4 – "the platoon maintains local security throughout the movement" was not performed correctly. A problem statement is clear only if it is stated in terms of a doctrinal, collective/individual training task/drill. This is a correct problem statement if it results in the correction of the original outcome. Thus, if the platoon corrects its actions concerning security during movement, then the enemy will not surprise the unit's main body. If this does not correct the outcome of the unit being surprised, then a different problem task must be found.

Problems that were not specified in the doctrinal structure outlined above were not counted. The reason for this is that the Army training system (Chapter I) is designed to correct problems that conform to this structure. This is a basic premise of the standardization of battle focused training across the Army. (DA, FM 25-101, 1990) Without a standardized training process the Army does not have a common language to communicate and correct performance problems. Thus, to avoid subjective interpretation of message content, issue and solution tasks and task standards/performance measures were only counted if expressed in terms of doctrinal training terms. Likewise, conditions for the future training plan had to be articulated with respect to METT-T or other doctrinal terms.

The BDA from an engagement is used to determine the correct root problem and "why" it was a problem. In the above case, the BDA would need to be examined to determine if *perform local security* was a problem for the unit. The following BDA would be relevant to the articulation of the problem:

- Who saw the other first;
- Who shot first;
- Length of time required to place controlled fire on the enemy; and
- The number of casualties and equipment losses that occurred before and during the initial engagement.

The BDA will reveal the root training problem via cause-effect analysis. The number of casualties and equipment losses are the consequence of the unit's actions or inaction. This information signifies the elements of performance that contribute most directly to the outcome.

The solution should then describe how task performance is to be corrected or improved in terms of the training conditions and any other related tasks and subtasks that affect the stated performance measures. Using the example above, the solution must identify the actions (supporting subtasks) required to maintain security during movement under the specified training conditions. The training conditions are identified in terms of the unit's and enemy's mission, intent, and organization; the terrain considerations; and the time available for planning, preparation, and execution. Given the training conditions, the supporting subtasks and associated performance measures to achieve local security make up a clear solution. This data variable is labeled *solutions developed.*

The next step is to articulate how to train the root problem tasks in the future. This includes the identification of the necessary training conditions and performance

measures that must be met in retraining. The result is a training plan – the task, conditions, and standards that must be performed and met to correct the weakness. These are labeled *solutions planned.* The difference between a *solution developed* and a *solution planned* is the context to which each applies. The *solution developed* concerns corrective actions that are required to affect performance improvement in the training scenario just conducted. A *solution planned* pertains to the corrective actions required to ensure the weakness is not repeated (during task execution) given *any* set of battlefield conditions.

For a *solution planned* to be counted, it must meet a feasibility criterion. This criterion is that the prescribed retraining task, conditions, and standards must be feasible enough for unit leaders to implement with the resources available to them. This translates to the appropriate amount of time, logistical support, training system, and land being available at the unit's home-station. Subject matter experience indicates that most unit members automatically limit themselves to the resources immediately available when planning training; exceeding those resources is often unimaginable for them.

An example of a *solution planned* to correct the problem of perform local security for the collective task Perform Tactical Roadmarch is as follows. Assume that a platoon was moving in the least secure vehicular movement formation at the time of the surprise enemy attack. A viable training solution may be to train leaders on a terrain model to analyze the enemy situation with respect to the terrain in order to predict likely enemy ambush positions. This is reasonable because combat units have access to a terrain model

most of the time and it takes few resources to coordinate and execute the training. An unreasonable training solution would require resources that the platoon leadership does not control.

To measure the quality of the learning points, the following were counted:

- The number of *solutions planned* – problem tasks described, solved, and planned for future training with feasible task, conditions, and standards;
- The number of *solutions planned* with task, conditions, and standards that are not feasible with respect to training;
- The number of *solutions developed* – problem tasks described and solved without corrective training actions articulated;
- The number of problem tasks identified without adequate description of training conditions and performance standards or any solution at all;
- The number of ill-defined issues (abstract problems or solutions not associated with a doctrinal task or performance standard).

Of course, the number of issue tasks identified with a feasible retraining plan should not be a large number. Doctrinal, JRTC, and NTC guidance recommend that two to four learning points be fully developed during the AAR. (DA, TC 25-20, 1993, JRTC/BDM, 1993, and NTC/BDM, 1992) Therefore, the number of *solutions planned* and/or *developed* is not as important as the fact that there were <u>some</u> *solutions planned* and/or *developed* rather than none.

Learning occurs in the participant's articulation and elaboration during the discussion. The participant, rather than the AAR leader, must articulate and elaborate on the task specific strengths, weaknesses, and factors that influenced performance and then develop a retraining plan to correct or reinforce behavior. For this reason, the tracking of fully developed issues and solutions is an objective, albeit relative, measure of unit learning that occurred during the AAR. But if the participant can verbally articulate the subject, then there is a strong probability that he knows the subject. Hence, a unit that articulates a number of planned and developed solutions has a better chance to improve performance than a unit that does not. Furthermore, the unit will collectively accept the solution and be more likely to implement it if it was developed by a unit member rather than an outsider. Unit members are more credible to each other because they are familiar with the organizational climate, resources, and problems, and have to live with or share the solution's consequences with the others.

Time Dependent Variables

Time is the final measure of effectiveness considered in this survey. Each CTC sets AAR time limits that are given to the unit prior to the AAR. Unless the AAR leader states otherwise, the trainees expect the AAR to last no longer than the allotted time. Hence, they understand that they must remain attentive throughout the AAR. For the JRTC, platoon and company AARs are allotted 60 and 120 minutes respectively. At the NTC, platoon and company AARs are allotted 45 and 90 minutes respectively. For this

survey, it will be noted whether or not the AAR exceeds the designated time limit. The number of trainees sleeping during the AAR can also indicate that the AAR is too lengthy or that the AAR leader is unskilled at soliciting participation.

The length of time spent on each stage of the AAR was also recorded. The AAR stages correspond to the AAR agenda followed by each AAR leader. Although specific agenda items vary between AARs, they generally follow the doctrinal guidance outlined in TC 25-20. (Table 3.3, Doctrinal AAR Format) The allocation of time in accordance with the agenda shows how much of the AAR time (in minutes) was used for administrative topics, introduction topics, discussion, and conclusion topics. Many of the introduction and conclusion topics are required by doctrine. The number of questions and comments by each participant was recorded from items 4, 5, and 6 of the doctrinal AAR format. These items are the *discussion of key issues*, *discussion of optional issues*, and *discussion of force protection issues*. In the other sections of the AAR, doctrinal guidance does not require participatory discussion. (DA, TC 25-20, 1993) The limits of the discussion period were defined by the AAR leader and the agenda. Thus, when the AAR leader moved from the *summary of recent events* to the *discussion of key issues*, the discussion period began. The discussion period ended when the AAR leader began the *closing comments and summary* portion. It was also qualitatively noted if the AAR leader followed the doctrinal AAR format or created his own.

Table 3.3, Doctrinal AAR Format

1. *Introduction and rules.* The AAR leader describes the purpose and sequence of the AAR emphasizing that "the AAR is not a critique" and all should participate in the discussion to improve performance.

2. *Review training objectives and intent.* The training objectives, friendly and OPFOR commander's mission and intent, and relevant doctrine, tactics, techniques, and procedures are reviewed.

3. *Summary of recent events.* Using leading and open-ended questions, the AAR leader guides a discussion of the logical sequence of events.

4. *Discussion of key issues.* The AAR leader uses a discussion technique to help participants discover strengths/weaknesses, develop solutions, and designate corrective action. The three discussion technique structures available are: a chronological order of events, the seven Battlefield Operating Systems (BOS), and key events/themes/issues.

5. *Discussion of optional issues.* The AAR leader has the option to lead the discussion to the topics of soldier/leader skills, tasks to sustain/improve, statistics, or other topics.

6. *Discussion of force protection issues.* This is a mandatory topic. It covers all aspects of soldier safety in the field and in garrison and is emphasized throughout the AAR.

7. *Closing comments and summary.* The AAR leader reviews and summarizes learning points from the discussion and future training tasks and conditions.

(DA, TC 25-20, 1993, 1-3 and Chapter 4)

AAR Leader and Unit Actions – Independent Variables

Nine other qualitative observations made during the survey are effectiveness indicators identified in the literature review. These observations are listed below and then discussed.

- Introduction establishing a non-threatening, participatory climate (Downs et al., 1987);
- Clear review of training objectives and executed plan (SHERIKON, 1996);
- Use of specific, non-qualitative performance feedback (SHERIKON, 1996);
- Use of a 3-D terrain model/representation (Word, 1987);
- Depict performance results with pictures, sketches, and graphs (SHERIKON, 1996);
- OPFOR or OPFOR representative(s) participating in the discussion (Word, 1987).

As pointed out in Chapter II, each of these contribute to participation, discussion focus, or both. The last three observations are also factors that could possibly affect the unit's participation in the discussion.

- Unit attitude;
- Unit leader's actions to support a non-threatening, participatory climate.
- Participation feedback.

Downs et al. found that the AAR leader's emphasis of cooperation, participation, and open discussion in the introductory remarks had a strong effect on participation. (Chapter II, 30) In this survey, it was noted whether or not the AAR leader addressed this issue in the introduction or at any other time during the AAR. Examples of these statements are:

"The focus is on how to improve, not who to blame, be objective;"

"It is okay to disagree with a point being made;"

"This is your AAR, your discussion is important to determining what was good or bad about your performance, you decide;"

"The discussion is how we learn from what happened and I (the AAR leader) am here to learn also. I learn something new in each AAR I conduct."

This is not a complete list, but these statements are examples of what the AAR leader should be trying to communicate to meet the requirements of Downs' et al. (1987) conclusion. The AAR leader's statements were recorded for the survey and then transposed as qualitative data. If the AAR leader made similar statements, the data point was marked as a positive one (+1). If he did not make any statements of this type, the data point was marked as a negative one (-1).

SHERIKON stated that a clear review of the training objectives and executed plan was important to AAR effectiveness. (Chapter II, 42) This is important from the standpoint that it allows trainees to compare what should have happened according to the plan (training objectives) with what actually happened. For data collection, it was noted if the unit's plan was reviewed and if the comparison was made.

SHERIKON, Word, and Downs et al. all identified the need for specific, non-qualitative performance feedback or BDA. (Chapter II, 39) The most popular data used for this purpose is the number of casualties and equipment losses inflicted and received. For each AAR, it was noted whether or not the BDA was consolidated and presented during the AAR.

Word (1987) was the strongest advocate of the next observation – whether or not the AAR leader uses a 3-D representation of the terrain during the AAR. (Chapter II, 29) The terrain model helps visualization of: what happened and why, terrain considerations, and understanding singular actions in terms of the larger picture of events. Consequently, it aids participants in communicating their discussion points. It was noted if a terrain model was present and if it was used in each AAR.

SHERIKON and Word advocate the use of pictures, sketches, and graphs to depict performance results for the same reasons as stated above. Additionally, a number of studies show that humans can comprehend pictures, graphs, and tables much quicker than they do written or spoken words. (Chapter II, 42) For each AAR, it was noted whether or not any of these presentation formats or aids were used.

The next observation made in the survey was whether or not the OPFOR or member of the OPFOR participated in the AAR and/or discussion. Word and Bosley et al. pointed out the importance of OPFOR participation in the AAR. (Chapter II, 28 and 29) Their actions largely determine what the friendly unit saw and acted upon during the training. Hence, they are important for identifying and explaining the factors that caused the performance outcome. They also lend a new set of viewpoints and experience to the discussion of how to do things better.

Another item noted during the survey was whether the unit was hostile, argumentative, or defensive in attitude toward the AAR leader or each other. Examples of these attitudes are arguing and/or extensive complaining about: exercise rules of

engagement, OC actions, OPFOR actions considered unfair, and/or mission constraints imposed by the higher level of command. Although it is impossible to determine why the trainees may have such an attitude, it does detract from discussion participation and focus. Not much learning occurs when participants are personally attacking the AAR leader or are closed-minded to differing opinions. These comments were noted as administrative utterances and combined to indicate a defensive/argumentative, neutral, or positive/proactive learning attitudes.

The next research observation made during the AAR discussions was of the unit leader's actions. Specifically, whether or not the unit leader helped to prompt participation amongst the unit and focus the discussion on the problem issues. The unit leader can play a large part in curbing a hostile and/or defensive attitude(s). Essentially, he has the choice of actively facilitating the AAR, hindering the AAR, or ignoring the opportunity to influence the AAR at all. The unit leader's explicit comments related to this choice were noted as administrative utterances. Comments or open-ended questions that were related to the discussion are noted as discussion utterances.

The last discussion observation is the AAR leader's provision of participation feedback to the trainees. From subject matter experience it seems that declarative remarks that laud participation and/or highlight non-participation prompt the trainees to participate in the discussion. Examples of theses remarks are:

"You guys need to talk this out, what do you think about this (problem)?"

"Good point, what do the rest of you say? Do you agree?"

"You're not participating in the discussion, do you think what he said is true?

Why (or why not)?"

"That is a valid point, good job on pointing it out!"

"You guys are not contributing; they are talking about a problem that affects you.

Say what *you* think."

"Good job (everyone) on discussion; keep it up."

These remarks serve to remind the trainees that discussion participation is an objective of the AAR. They are also classic examples of discussion facilitation – one of the AAR leader's primary responsibilities. (DA, FM 25-101, 1990, and TC 25-20, 1993) Oddly enough, providing participatory feedback is only implied in the doctrinal references. Open-ended and leading questions are specifically designated as facilitation techniques.

Methodology

The JRTC and NTC were solicited for platoon and company level tapes of actual AARs. The tape selection criteria for each training center was as follows: select five each platoon and company AAR tapes, select from rotations that occurred in the past few years, select AARs led by different AAR leaders, select AARs from infantry or armor units, and select AARs from different units. The result of this request was the receipt of 9 platoon and 7 company level AAR tapes from the CTCs. An additional company level JRTC AAR from my personal library was also included for a total of 17 AARs. The AARs were all conducted within a recent 15 month span. None of the AARs were

conducted by the same AAR leader and all were of different platoon and company units. The type of each unit is listed in Table 3.4, AAR Survey – Unit Types. For the platoon AARs, attendance ranged from 16 to 45. Company level AARs involved only key leaders and the company headquarters section so attendance ranged from 7 to 16 depending upon the number of attached units.

Table 3.4, AAR Survey – Unit Types

Echelon	Type	Number
Platoon	Infantry, Light	6
Platoon	Infantry, Mechanized	2
Platoon	Armor	2
Company	Infantry	4
Company	Armor	1
Company	Infantry-Armor Team	1
Company	Armor Heavy Team	1

The survey of 17 AAR tapes was conducted over a 14 day period. Except for 4 days, 1 tape was surveyed per day. The data collection was conducted by two observers, one watched and listened to the AAR leader while the second concentrated on the other participants. Two JRTC platoon AARs that were not included in the survey were used

for data collection practice. This allowed the data collectors to proceduralize the collection process before beginning the survey.

Since the AAR leaders dominated the discussions in the majority of AARs, the observer attending (listening and watching) to the trainees made notes of discussion focus and other observations (agenda, time records, effectiveness indicators, and unit attitude). This person is an active duty, Infantry Major with over seven years troop experience and two years CTC experience at the JRTC. The priority of effort for data collection was to participatory comments first, then to discussion content, and lastly to the other observations. When the pace of recording both participatory and discussion data prevented collection of the tertiary priority data, the AAR was viewed a second time in order to collect the data on the other observations.

As stated before, the second data collector counted the number and type of utterances the AAR leader made. This observer has a Bachelor of Science in Sports Journalism with ten years writing and reporting experience in the fields of sports, education, and marketing. Additionally, she is familiar with the military vernacular, as well as military terms and symbols.

Analysis

The data from each AAR was recorded on preprinted forms and then transcribed to a spreadsheet for analysis. The small number of AARs allowed the raw data to be consolidated into two tables. The aim of this analysis was to determine what factors and

variables seem to affect participation and discussion focus. First, a trend analysis of each factor was conducted. This followed the same lines of inquiry that were followed in the analysis of the Downs et al. (1987) data. (Chapter II)

The second part of the analysis was to use univariate multiple regression to confirm any trends found. The regression analysis was conducted with MINITAB for Windows software. (Appendix B, Regression Analysis) All regression models were tested to a statistical significance level (α) of 0.05. Multiple regression analysis was conducted for each of the dependent variables using the least squares method. (Scheaffer & McClave, 1995, 541 through 590) This analysis indicated which factors (AAR leader and unit actions) were statistically significant and seemed to have a large or small effect on a selected dependent variable. First, a dependent variable is modeled with all of the independent variables. Then, insignificant independent variables are individually removed from the full model. The insignificance of a variable is determined by a F-test achieved (at $\alpha = 0.05$). The objective in this process is to minimize the summed squares of error and maximize the model's coefficient of determination (R^2, a measurement of model adequacy). The removal of variables continues until a reduced model of least squares is. The multicollinearity amongst the regressor variables was tested using eigen analysis. (Myers & Montgomery, 1995, 656 through 662) For each model, the variance inflation factor (VIF) for the smallest eigenvalues was computed. A VIF ≥ 100 was considered large and an indication of multicollinearity. The regressors that did not pass the test were reanalyzed and either combined or removed from the model altogether.

Data

The quantitative dependent variables selected to describe the factor of discussion participation are listed below. A consolidated list of variables and their definitions is in Appendix B, Regression Analysis, Table B-1, Factor Definitions.

- Unit:AAR leader utterance ratio – total unit utterances to total AAR leader utterances.
- Percent (%) unit participation – number of unit discussion participants over total

  number of unit attendees.
- Unit comment:AAR leader question ratio – total number unit comments to total AAR

  leader questions.
- Number of questions asked by the unit during the discussion.
- Number issues discussed amongst unit members without the AAR leader's prompting

  or intervention.

The observations for each AAR are listed in Table 3.5, Discussion Participation Data.

The dependent variables that describe discussion focus were *solutions planned* and *solutions developed.* These two measures were further subdivided between Unit specified solutions – the number planned and developed by the unit, and Total specified

solutions – the number planned and developed by both the unit and the AAR leader together. This data is listed in Table 3.6, Discussion Focus Data.

The AAR leader actions that are hypothesized to affect the effectiveness of the AAR are shown in Table 3.7, AAR Leader Actions Data, and Table 3.8, Unit and Other Actions Data. These actions are qualitatively coded – either they were or were not performed. The code for an action performed is +1 (positive one) and the code for not performed is -1 (negative one); a 0 (zero) code represented a level between +1 and -1.[8] The introduction establishing a participatory climate, unit attitude, and unit leader facilitating discussion were all actions that used three qualitative levels. For example, the introductory comments that warrant a "0" code are ones that are stated quickly, from rote memory, or read from a preprinted card. Only comments that added emphasis to a point were given a code of +1. Likewise, unit attitude and unit leader facilitation were coded with a 0 if they were neither positive nor negative in content.

[8] For the regression analysis, all variables were represented as two coded levels, "1" and "0." When a third condition had to be represented, an additional two level variable was added.

Table 3.5, Discussion Participation Data

AAR #	Unit to AAR Ldr Utterance Ratio	% Unit Participation in the Discussion	Unit Comment to AAR Ldr Question Ratio	AAR Time used for Discussion	Questions Asked by Unit	Questions Asked by AAR Ldr	Discussion Amongst Unit
1	0.22	72	0.67	92	2	219	0
2	0.29	67	1.14	91	5	120	0
3	0.85	100	1.32	85	65	314	1
4	0.61	63	1.63	77	0	159	0
5	1.07	100	2.2	86	5	98	1
6	1.62	74	2.98	58	6	116	0
7	0.51	76	1.01	86	1	367	0
8	0.56	78	1.11	85	1	320	0
9	0.4	87	0.85	84	3	300	0
10	0.43	100	1.48	24	0	107	0
11	0.67	100	1.65	83	2	144	0
12	1.09	100	2.24	90	42	194	1
13	1.24	92	2.93	52	12	72	0
14	2.01	92	4.66	71	69	129	1
15	0.96	83	3.04	58	1	75	0
16	0.47	69	1.57	75	2	109	1
17	0.6	75	0.98	63	0	294	0

Table 3.6, Discussion Focus Data

	Specified by Unit (during AAR):					Total Specified (during AAR):				
AAR #	# Solutions Planned (T,C,S)	# Solutions Developed (T,C,S)	# Tasks, Conditions w/o Standards	# Tasks w/o C, & Stds	# Issues w/o T,C,S	# Solutions Planned (T,C,S)	# Solutions Developed (T,C,S)	# Tasks, Conditions w/o Standards	# Tasks w/o C, & Stds	# Issues w/o T,C,S
1	0	0	1	6	6	0	1	2	12	21
2	0	0	0	0	5	0	2	4	13	26
3	1	3	9	14	14	1	4	9	14	14
4	0	2	1	6	6	0	2	2	9	13
5	0	2	3	4	0	0	4	4	9	1
6	0	0	1	6	1	0	1	1	6	7
7	0	0	0	0	0	0	1	2	4	3
8	0	0	0	0	0	0	0	0	4	16
9	0	1	1	1	7	0	3	3	10	10
10	0	0	1	1	0	0	3	4	6	5
11	0	1	1	2	4	0	2	4	6	8
12	2	2	3	2	0	2	3	3	3	3
13	0	1	2	4	13	0	2	2	7	17
14	1	4	4	5	10	1	4	4	6	14
15	0	1	5	6	7	0	1	8	7	7
16	0	0	1	1	8	0	1	1	8	10
17	0	0	0	0	0	0	2	2	9	6

Table 3.7, AAR Leader Action Data

AAR #	Focused Open Questions	Focused Leading Questions	Provided Participative Feedback	Exceeded Time Limit	Followed Doctrinal Format	Introduction Establishing a Participative Climate	Used Specific BDA	Used Terrain Model	Used Pictures & Sketches to aid Discussion
1	-1	-1	-1	-1	1	0	-1	-1	1
2	-1	-1	-1	1	1	0	-1	-1	1
3	1	1	1	-1	1	1	-1	-1	1
4	-1	1	-1	1	1	1	-1	-1	1
5	1	1	-1	-1	1	0	1	1	-1
6	-1	-1	-1	-1	1	1	-1	-1	1
7	-1	-1	-1	1	1	1	-1	-1	1
8	-1	-1	-1	1	1	1	-1	-1	1
9	-1	-1	-1	-1	1	1	-1	-1	1
10	-1	-1	-1	-1	1	0	-1	-1	-1
11	-1	-1	-1	1	1	1	-1	-1	1
12	1	1	-1	-1	1	1	1	-1	1
13	1	-1	-1	1	1	1	1	-1	1
14	1	1	1	1	1	1	1	-1	1
15	1	1	-1	1	1	0	-1	-1	1
16	-1	-1	-1	1	1	0	-1	-1	1
17	-1	1	-1	1	1	1	-1	-1	1

Table 3.8, Unit and Other Actions Data

AAR #	Unit Attitude	Unit Leader Aided discussion	OPFOR Participation in discussion
1	0	0	-1
2	-1	-1	-1
3	0	0	-1
4	-1	0	-1
5	0	0	-1
6	0	0	-1
7	-1	0	-1
8	0	-1	-1
9	0	0	-1
10	-1	0	0
11	0	0	-1
12	1	1	0
13	0	0	-1
14	1	1	-1
15	-1	-1	-1
16	0	-1	-1
17	-1	-1	-1

Results

Findings

The findings of this survey are summarized below. Of the 17 AARs, 4 were found to have a high degree of trainee participation in the discussion *and* were discussion focused. In the summary below, the "majority of AAR leaders" or "AARs" refers to the 13 that did not achieve high participation and specify problem solutions. The reciprocal

of this, the "minority" of AARs or AAR leaders, refers to the 4 participatory and discussion focused AARs that did specify performance problem solutions.

- All 17 AAR leaders followed the doctrinal AAR format outlined in TC 25-20 (1993). (Table 3.3, Doctrinal AAR Format)

- In the majority of AARs, unit member participation in the discussion is low relative to the AAR leader.

- The majority of AAR leaders are either unskilled at using open-ended and leading questions or do not use them at all.

- The majority of AAR leaders do not ensure that all of the unit members are involved in the discussion.

- The majority of AAR leaders do not provide participatory feedback during the discussion.

- The majority of AAR leaders do not use doctrinal performance standards nor specific performance feedback to focus discussion.

- OPFOR representatives and 3-D terrain models are not used to prompt, focus, nor facilitate AAR discussion.

- The majority of AAR leaders and units do not summarize nor express strengths/weaknesses (lessons learned, or issues discussed) in terms of a problem task, conditional factors that affect performance, and performance standards.

• The majority of AAR leaders did not require units to link performance, corrective actions to solve problems, nor problem solutions of any type to subsequent training.

Given these findings, an additional observation can be made with respect to AAR doctrine outlined in TC 25-20. The doctrinal key points of an AAR were not satisfied by the majority of the 17 AARs. These points were reviewed in Chapter I (pp. 19 through 22) and, except for one, are listed in Table 3.9, Key Points of an AAR. This table lists the key point and the percentage of AARs that satisfied the point. All of these points concern either participation or discussion focus. The point that was not listed is concerned with timeliness of the AAR which could not be measured.

Table 3.9, Key Points of an AAR

Key Point	Percentage of AARs Meeting Criteria
AARs should focus on the intended training objectives	100
AARs should focus on individual and collective performance	100
AARs relate to specific performance standards	30
AARs involve all participants in the discussion	24
AAR leaders use open-ended and leading questions to prompt and guide discussion	30
AARs determine strengths and weaknesses	94
AARs link performance to subsequent training	12

(DA, TC 25-20, 1993)

For the determination of strengths and weaknesses, an AAR was considered as satisfying this point if someone identified a topic, area, or task as such. The point is that if strengths/weaknesses were required to be specified in doctrinal training terms, the percentage meeting this criteria would drop to 30%. Furthermore, if the strengths and weaknesses dictated by the AAR leader are not counted, then the strengths and weaknesses percentage drops from 94% to 53%. The bottom line for all of these points and findings is that AARs are not being conducted as participatory discussions focused on improving performance. Instead, the majority of AARs resemble a classroom lecture. AAR leaders at the JRTC and NTC are not implementing doctrinal guidance when conducting AARs. Furthermore, if CTC AARs are the example for the Army, then a majority of units, design engineers, and researchers are observing ineffective AARs in terms of discussion participation and focus.

Notwithstanding, the minority of AARs surveyed – the 4 participatory, discussion focused AARs – are exemplary. The multiple regression analysis revealed that the actions of these 4 AAR leaders are correlated at a significance level of 0.05. All 4 AAR leaders:

- Emphasized participation and discussion focus in their introductory remarks;
- Provided participatory feedback to the unit to prompt discussion – they required unit members to talk;
- Used open-ended questions to prompt discussion and leading questions to guide discussion;

- Used specific BDA (objective measures of performance) to focus the discussion; and
- Focused discussion on solving a specified problem in terms of the problem task, conditions that affect performance, and performance standards; (2 of the 4 also focused on how to train the problem task in order to achieve the desired performance outcome)

All of these actions are in accordance with or directly support doctrinal AAR guidance.

Discussion

The 17 AARs had a number of commonalties that could not be used in any differentiating or regression analysis. Specifically, these were:

1. The AAR leaders all followed the doctrinal format. (Table 3.3, Doctrinal AAR Format)
2. None of the AAR leaders used a terrain model nor sand table during their AAR. However, one AAR leader did use the actual terrain in the same way a model would be used.[9] He conducted a terrain walk for part of his AAR.
3. OPFOR representatives did not participate in the discussion portions of the AAR. In fact, all JRTC OPFOR representatives, except one, departed the AAR before discussion began. OPFOR representatives did not attend any of the NTC AARs.

The doctrinal format observation is not surprising given the emphasis that the CTC guidance documents and chain of command place on this. Essentially, this has the effect

[9] AAR # 5.

of standardizing the AAR format across the Army. The benefit is that commanders and units are all familiar with the system and have common examples of its implementation. Hence, this reinforces the use of the doctrinal format in AARs for home-station training.

At platoon level, the nonuse of a terrain representation as an aid is also understandable in light of the short time period allowed for AAR preparation. At the CTCs, the exercise is free-play. OCs can usually guess the general location of contact, but not closely enough to build a detailed terrain model of the area in time for the AAR. It is even harder to predict the exact location of the AAR itself. Only if the contact took place in a relatively small area (200 meter by 200 meter box) is using the actual terrain an effective technique to aid the unit's visualization of the battlefield and task performance.

There is less justification for not building a 3D representation of the terrain at the company level. AAR preparation time is 4 hours and 2 hours respectively at the JRTC and NTC. There is also manpower available. The NCOs not participating in the platoon AAR are available during this change of mission period. However, from personal experience at the JRTC, the use of terrain models during AARs was not advocated.

OPFOR representatives at the JRTC were either platoon leaders or squad leaders that had opposed the unit during the exercise. All of these representatives recanted their mission and intent statements, the concept of operation, and actual execution of their plans. They also presented observations of unit performance from their perspective. The unit was then allowed to question the OPFOR. Of the 10 AARs in which this occurred, none of the units questioned the OPFOR about their observations. Instead, the units

asked trivial questions usually intended to confirm or deny the unit's perceived stereotype of the OPFOR. Typically, the unit tried to ascertain what equipment or information the OPFOR possessed that had given them an advantage. The longest questioning period lasted 9 minutes.[10] In this case, the unit asked questions concerning the OPFOR disposition and composition. There was no discussion of the unit's questions beyond clarification of the answers.

Discussion Participation

Discussion participation is defined by the six dependent variables listed in Table 3.5, Discussion Participation Data. In 5 of the 17 AARs, 100% of the attendees made one or more declarative statements (comments) during the AAR.[11] Of these, the AAR leaders made concerted efforts to ask each of the unit members a question. In 2 other AARs, attendee participation was 92%.[12] The participation rate of the other 10 AARs ranged from 87% to 63%. Of the 7 AARs where the participation rate was 92% or higher, the Unit : AAR leader utterance ratio was above 1.00 in 4 cases. In other words, the unit produced as many or more comments with respect to the AAR leader in 4 AARs. Less these 4, the comment ratios of the other 13 AARs ranged from 0.96 to 0.22.

Another aspect of participation that was measured was whether or not discussion amongst the unit members, without the prompting from the AAR leader's questions, occurred. Discussion without the AAR leader occurred in 5 of the 17 AARs; 3 of these 5

[10] AAR # 13.

belong to the set of participatory AARs – AARs with an attendee participation rate above 92% and Unit : AAR leader utterance ratio of 1.00 or greater.[13] The participatory AAR that did not have any internal discussion amongst the trainees also had the only AAR leader of the 4 that did not employ both open-ended and leading questioning techniques. Of the 5 AARs in which inter-trainee discussion occurred, 4 of them had AAR leaders that employed both open-ended questions and leading questions. The converse of these numbers is that the discussion in 76% of the AARs (13 of the 17) can be described as an interchange between the AAR leader and one attendee at a time.

A measure similar to the Unit : AAR leader utterance ratio is the Unit comment : AAR leader question ratio. This ratio is more revealing of how much the unit commented beyond replying to the AAR leader's questions. For all of the AARs, this ratio value ranged from 4.66 to 0.67. There are 6 AARs with Unit comment : AAR leader question ratios greater than 2.00.[14] However, two of these ratio measures are misleading. In the first, unit comments were increased by the AAR leader's requirement of unit members to read text from doctrinal references.[15] In other words, these were not comments unit members made of their own volition. The second case involved a unit and a commander with particularly poor attitudes.[16] The commander made a point to comment on each unit member's comment. His complaining and arguing about rules of

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[11] AAR # 3, 5, 10, 11, and 12.
[12] AAR # 13 and 14.
[13] Discussion amongst the unit members occurred in AAR # 5, 12, 14, and 16. AAR # 5, 12, and 14 have high participation rates and high Unit : AAR leader utterance ratios.
[14] AAR # 5, 6, 12, 13, 14, and 15.
[15] AAR # 6.

engagement and unfair treatment falsely increased the comment ratio of the unit. The other 4 AARs with Unit comment : AAR leader question ratios above 2.00 were the same 4 AARs that had Unit : AAR leader utterance ratios above 1.00 and participation rates above 92%.[17]

Overall, the majority of AARs exhibited a low degree of trainee discussion participation. A plausible explanation for this lack of participation is Chris Argyris' theory of organizational learning. Argyris is the James B. Conant Professor at the Graduate School of Business, Harvard University and has completed extensive studies and consulting contracts in organizational behavior. On Organizational Learning (1994) is the result of his work and experience in this field. In it, Argyris outlines two models that explain how and why individuals in organizations interact. These are Model I and Model II. These models consist of a set of goals that he has observed people to prevalently use in a number of organizational settings. They are evolutionary in that, with guidance, an organization can evolve from Model I to Model II. (Argyris, 1994) Although Argyris does not seem to have studied any military organizations, Model I does provide insight into the individual's natural resistance to participation in an AAR.

Argyris' Model I goals that dominate individual behaviors are summarized in Table 3.10, Model I Governing Variables. These governing variables are the goals each individual endeavors to achieve in daily interactions with others. To achieve these goals, people universally implement the same strategies. These are to: 1) "advocate your

[16] AAR # 15.

Table 3.10, Model I Governing Variables

	Individual's Goal
1.	Strive for unilateral control.
2.	Minimize losing and maximize winning.
3.	Minimize the expression of negative feelings.
4.	Be rational – do not do anything illogical.

(Argyris, 1994, 26 and 150 to 151)

views without encouraging inquiry" in order to obtain unilateral control of the interaction and "win" your point, and 2) "unilaterally save face – your own and [if possible] other people's" in order to minimize upsetting others' pursuit of the same goals or "making them defensive." Each individual learns these goals and strategies socially throughout his formative years. (Argyris, 1994, 26)

Obviously, people acting out Model I behaviors will be resistant to any situation or person that prevents them from doing so. Thus, in AARs the hesitance or resistance to participation in a discussion can be accounted for by Model I. Each individual naturally wants to avoid embarrassment, first of himself and second of others. Furthermore, if one cannot advocate his opinion without being questioned about it, he is less likely to volunteer the opinion in the first place. This environment is typical of an AAR. As Argyris found in so many of his case studies, individuals who are placed in these types of

[17] AAR # 5, 12, 13, and 14.

environments resist saying anything at first, then become argumentative and employ defensive reasoning strategies when forced to participate. (Argyris, 1994)

Given that a high rate of participation, large comment ratio, and discussion amongst the unit are all desirable, the 4 AARs that meet this criteria require some scrutiny. In all but 1, the AAR leader employed both focused, open-ended and leading questions. In the exception, the AAR leader only used focused, open-ended questions.[18] This exception is also the only one of the group in which discussion without the AAR leader did not occur. In all 17 AARs, 5 AAR leaders used both focused, open-ended and leading questions; 3 AAR leaders employed one or the other type questions; and 9 AAR leaders used neither.

Additionally, the 4 leaders of the participatory AARs were the only ones to use specific, non-qualitative BDA during the discussion portions of the AAR. Terrain and contact sketches were also used to aid discussion in 3 of the 4 AARs. The AAR leader who did not use sketches used the actual terrain instead.[19] He walked the unit along the objective so that unit members could explain what happened, where it happened, and why. Hence, the terrain walk substituted for the sketches. A total of 15 AAR leaders referenced large maps and terrain and contact sketches at some point in the discussion.

Other characteristics of these 4 AARs were unit attitude and unit leader facilitation actions. Half of the 4 were rated as neutral (qualitative code of "0") for both

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[18] In AAR # 13, the AAR leader did not use leading questions.
[19] AAR # 5.

unit attitude and leader helpfulness, and the other 2 AARs were rated as good (qualitative code of "1") for both factors.[20] Of all 17 AARs:

- 3 units had a poor attitude and an unit leader who made negative comments (qualitative code of "-1");[21]
- 3 units had a poor attitude and an unit leader who was neutral, but did not correct the unit's attitude;[22]
- 2 units had a neutral attitude and a leader who made negative comments;[23]
- 7 units had a neutral attitude and a neutral leader;[24] and
- 2 units had a positive attitude and a leader who proactively aided the AAR process.[25]

Unfortunately, 8 of the 17 AARs had a unit with a poor attitude, a leader with a poor attitude, or both. Thus, half of the units displayed tendencies in keeping with Argyris' Model I behaviors. (Argyris, 1994) Experience in and with combat arms units suggests those that habitually assess themselves against established performance standards are not argumentative, defensive, nor hostile. These units look for solutions rather than excuses.

<u>AAR Leader and Unit Actions Affecting Discussion Participation</u>

[20] AAR # 5 and 13 received scores of "0" and AAR # 12 and 14 received scores of "1."
[21] AAR # 2, 15, and 17.
[22] AAR # 3, 7, and 10.
[23] AAR # 8 and 16.
[24] AAR # 1, 3, 5, 6, 9, 11, and 13.
[25] AAR # 12 and 14.

Regression analysis confirmed a number of the trends found in the previous analysis. The models are summarized in Tables 3.11, Participation Factors, and 3.12, Discussion Focus Factors. The dependent variable and five independent variables that had the largest effect are listed for each model. Each effect's relative order of magnitude is given in parenthesis. This order of magnitude is only relative to the other effects within the equation. This number is not comparable between models. The coefficient of determination (R^2) for each model is listed in brackets beneath each dependent variable (leftmost column of the table).

The first dependent variable analyzed was the Unit : AAR leader utterance ratio. (Appendix B, Output B-2) At a statistical significance level of 0.05 and a $R^2 = 90.3\%$, the factors that had the largest effect on this variable were: the AAR leader giving an introduction that emphasized participation, the AAR leader's use of open-ended and leading questions, and the AAR leader providing participatory feedback to the unit combined with the use of sketches/large maps during discussion. Respectively, an introduction emphasizing participation and the interaction of open-ended and leading questions affected the utterance ratio 3.6 and 3.0 times more than the independent variable with the smallest effect (the use of specific BDA). The interaction of participatory feedback and the use of sketches/enlarged maps was 1.9 times the lowest order of magnitude in effect. These are actions that were present in the AARs with a higher Unit : AAR leader utterance ratio.

Table 3.11, Discussion Participation Factors

Dependent Variable	Independent variable w/the largest effect	Independent variable w/2nd largest effect	Independent variable w/3rd largest effect	Independent variable w/4th largest effect	Independent variable w/5th largest effect
Unit : AAR leader utterance ratio [R^2=90.3%]	Introduction establishing a participatory climate (3.6)	Interaction: used leading & open-ended questions (3.0)	Number questions asked by AAR leader (-2.0)	Interaction: Participatory feedback provided to Unit & used sketches/maps (1.9)	Unit specified *Solutions planned*[26] (-1.7)
% Unit Participation in the Discussion [R^2=52.7%]	Used sketches & maps in discussion (1.5)	Interaction: Used leading & open-ended questions (1.3)	AAR exceeded specified time limit (-1)		
Unit comment : AAR ldr question ratio [R^2=95.4%]	Interaction: Participatory feedback provided to Unit & used specific BDA (3.5)	Used open-ended questions (1.5)	Number questions asked by AAR leader (-1.2)	Unit specified *Solutions planned* (-1.1)	Introduction establishing a participatory climate (1.1)
# Questions asked by the unit [R^2=96.7%]	Participatory feedback provided to Unit (2.4)	Unit leader aided discussion (1.0)	Interaction: used open-end questions & Intro establishing a participatory climate (1.0)		
Discussion amongst unit members [R^2=69.8%]	Unit specified *Solutions planned* (5.0)	Interaction: used open-end questions & specific BDA (4.0)	Interaction: used specific BDA & sketches/maps (-4.0)	Introduction establishing a participatory climate (-1.0)	

(Appendix B, Regression Analysis, Outputs B-2, B-3, B-4, B-5, and B-6)

[26] This variable is a qualitative condition, either the unit specified *solutions planned* or they did not. These exclude those specified by the AAR leader.

The number of questions asked by the AAR leader and the unit action of discussing *solutions planned* had a negative effect on the unit speaking more than the AAR leader. The presence of variables with a negative (-) effect indicates that the majority of AARs did not perform those actions (regressor variables). Thus, a greater number of AAR leader questions did not lead to the trainees speaking more (relative to the AAR leader); and the discussion of *solutions planned* by the unit was not done in the majority of AARs.

The second dependent variable concerned how many of the unit members participated in the discussion. (Appendix B, Output B-3) However, the regression analysis was inconclusive because only 57.2% of the data's variance could be explained by the model (R^2 = 57.2%). This is not surprising since most of the AAR leaders were observed to specifically ask a question of each unit member. In fact, the most common AAR leader questions of a unit member concerned the assessment of something another unit member had stated or what that unit member had done at a specific point in the exercise. Many of these questions were of the form: is that right, Sergeant?; what do you think of that, Specialist?; or what were you doing at that time?; and what happened over there, Private? Hence, the participation rate does not strongly correspond with any of the AAR leader or unit actions measured.

The Unit comment : AAR leader question ratio was also analyzed as a dependent variable. (Appendix B, Output B-4) At a R^2 of 95.4%, the interaction between the AAR leader providing participatory feedback to the unit and using specific BDA during the

discussion had the largest effect on the unit submitting more comments relative to the number of AAR leader questions. The AAR leader's use of open-ended questions and an AAR introduction emphasizing a participatory climate also correlated with a higher Unit comment to AAR leader question ratio. The AAR leader emphasizing participation in the introduction, giving participatory feedback to the unit, and using open-ended questions were actions that were also present in the Unit : AAR leader utterance ratio model. This reinforces the suggestion that these AAR leader actions are the keys to unit members saying more and the AAR leader saying less. Likewise, the fact that the same actions, number of AAR leader questions and discussion of *solutions planned,* also showed up as negative effects again reinforces the point that they were not performed in the majority of AARs. The total number of questions asked by the AAR leader varied inversely with the ratio. Thus, in the AARs with a low comment to question ratio, AAR leaders still asked a large number of questions and the units did not discuss the subject of *solutions planned.*

The number of questions asked by unit members seemed to be positively influenced by the AAR leader's participatory feedback, the unit leader's help in facilitating the AAR, and the interaction of the AAR leader emphasizing participation in the introduction and then employing open-ended questions. (Appendix B, Output B-5) Participatory feedback had roughly twice the effect of the other two variables during the discussion. It should be noted that the variables for the unit leader aiding discussion and the unit having a positive attitude were highly correlated. This confounded the analysis and the two variables had to be combined. Since the unit leader is responsible for and in

the most influential position to affect the unit's attitude, the combined variables were defined qualitatively as "unit leader aided discussion" and "unit leader hindered discussion."

The last participation variable analyzed was discussion amongst unit members. (Appendix B, Output B-6) This was a dialogue between two or more unit members without the AAR leader intervening. At a $R^2 = 69.8\%$, this discussion corresponded with the unit specifying *solutions planned* and the interaction between the AAR leader's use of open-ended questions and specific BDA. The AAR leaders' introduction emphasizing participation and the interaction of specific BDA and sketch/map use negatively affected the model. This confirms that the majority of AARs did not have discussion amongst the participants occur spontaneously but still may have performed one or both of the independent variables: gave a participatory introduction and used open-ended questions in combination with specific BDA.

The models of Unit : AAR leader utterance ratio, Unit comment : AAR leader question ratio, and number of questions asked by the unit all had (high) R^2 values greater than 90%. On the other hand, the model describing the discussion amongst the unit was moderately adequate ($R^2 = 69.8\%$) and the one for percent participation did not describe the data well. Notwithstanding, none of these models contradict the trend analysis of the 4 participatory AARs. They do suggest some support for emphasizing participation in the AAR introduction, continuously providing participatory feedback to the unit, and guiding/focusing the discussion with open-ended and leading questions in order to

increase trainee discussion participation. The use of specific BDA and sketches/enlarged maps also were significant effects on participation.

The use of open-ended and leading questions both played roles in increasing participation. The use of open-ended questions varied directly with all the dependent variables except the percentage of the unit commenting during the discussion. This is most likely a result of following doctrine and the emphasis on participatory discussion. AAR doctrine states that the use of open-ended and leading questions is the recommended technique for the AAR leader to conduct the AAR. (DA, TC 25-20, 4-3)

There seems to be little doubt that the AAR leader's skill in engaging the trainees in the discussion, use of various aids, and participatory maintenance of the discussion all affect the level of trainee participation observed. Besides Argyris' theory (1994), the unit's previous AAR experience may be another plausible explanation for their low level of participation. The majority of unit's may never have experienced a participatory AAR. If feedback is always provided via lecture-critique, they would not know how to participate in a discussion of performance.

Discussion Focus

Solutions were developed in all but 1 (one) AAR.[27] For these 16 AARs, a total of 36 *solutions developed* were adequately articulated. However, only 3 of them adequately

[27] AAR # 8.

described *solutions planned.*[28] Of the 36 *solutions developed,* a total of 4 were resolved into *solutions planned.* Hence, the AAR leader or unit described feasible training tasks, conditions, and performance standards to correct identified problems in 18% of the AARs.

If the number of *solutions planned* and *solutions developed* by the unit are only counted, then the numbers are 4 and 17 respectively. In other words, removing the AAR leaders' contributions attributes less then half of the *solutions developed* and all of the *solutions planned* to the unit. Of the 4 *solutions planned,* 3 can be attributed to the AARs with high participation rates and comment ratios.[29] Of the 17 *solutions developed* by units, 9, or 69%, were developed in these high participation AARs.[30]

In the AARs in which solutions were developed and planned, the AAR leaders all continually emphasized that the solution was the objective of the discussion. In other words, each AAR leader guided the discussion to a specific end – a solution to the specified problem. Whereas the AAR leaders who did not achieve solutions in their AARs did not emphasize this objective continuously. In 12 of 16 AARs, the AAR leader stated that solutions to problems were the objective of the AAR in his introductory remarks.[31] This objective was continuously emphasized in only 3 AARs; the 3 AARs in which *solutions planned* were specified.

[28] AAR # 3, 12, and 14.
[29] AAR # 12 and 14.
[30] AAR # 5, 12, 13, and 14.
[31] The introduction of AAR # 16 was not filmed.

The lengths of the discussion periods were recorded for each AAR but were inconclusive. The discussion times were measured as a percent of the total AAR times. The values ranged from 92% to 24%.

AAR Leader and Unit Actions Affecting Discussion Focus

The regression models for the number of unit specified *solutions developed* and *planned*, and the total number of *solutions developed* and *planned* are summarized in Table 3.12, Discussion Focus Factors. The level of statistical significance for these models is an Alpha (α)of 0.05. Again, the number in parenthesis listed beneath each factor is the effect's order of magnitude relative to the other factors in the regression equation. Also, the models' R^2 values are bracketed beneath the dependent variable.

Reviewing Table 3.12, Discussion Focus Factors, it is obvious that the models of Unit and Total *solutions planned* are the same. At the same time, the models of Unit and Total *solutions developed* seem completely different. Since a unit first develops a solution before planning its implementation, the models of unit and total *solutions developed* will be investigated first.

In 9 of 17 AARs, the units specified *solutions developed.* The use of open-ended questions and the unit leader aiding discussion had the highest correlation with this dependent variable. The primary reason for this correlation is that these 9 AARs accounted for 100% of all the observations in which open-ended questions were employed and the unit leader helped.

Table 3.12, Discussion Focus Factors

Dependent Variable	Independent variable w/ largest effect	Independent variable w/2nd largest effect	Independent variable w/3rd largest effect	Independent variable w/4th largest effect	Independent variable w/5th largest effect
# Unit *solutions developed* [R^2=87.5%]	Used open-ended questions (1.8)	Unit leader aided discussion (1.6)	Unit leader hindered discussion (-1.4)	Used sketches & maps in discussion (-1.2)	AAR exceeded specified time limit (1.1)
# Total *solutions developed* [R^2=43.5%]	Participatory feedback provided to Unit (1.5)	Used specific BDA (1.0)			
# Unit *solutions planned* [R^2=99.7%]	Unit leader aided discussion (30)	Interaction: Participatory feedback provided to Unit &used specific BDA (-29)	# questions asked by unit (11.0)	Used specific BDA (-2.0)	Use of leading questions (1.0)
# Total *solutions planned* [R^2=99.7%]	Unit leader aided discussion (30)	Interaction: Participatory feedback provided to Unit &used specific BDA (-29)	# questions asked by unit (11.0)	Used specific BDA (-2.0)	

(Appendix B, Regression Analysis, Outputs B-7, B-8, B-9, and B-10)

The primary reason for the difference between the Unit and Total *solutions developed* models is the number of observations each dependent variable is based upon. While units specified *solutions developed* in 9 AARs, Total *solutions developed* were specified (by the AAR leader or the unit) in 16 of the 17 AARs. The model based upon a larger number of observations (16) had to account for a larger variability in AAR leader and unit actions. Many of the AAR leaders in those 7 additional AARs did not perform

the same actions as those leaders who led the 9 AARs with Unit specified *solutions developed.* This resulted in a low R^2 (43.5%).

The AAR leader actions that coincided with the Total *solutions developed* in the AAR (by either the AAR leader or the unit) were the provision of participatory feedback to the unit and the use of specific BDA during the discussion. Thus, the AAR leaders guided the AAR discussion with objective performance outcome data while continuously providing participation feedback to the unit. In other words, they emphasized unit discussion participation more than the other AAR leaders. This participation feedback went hand in hand with discussion focus feedback – explicit statements reminding the unit that the objective of the discussion was to solve the problem at hand.

The models for Unit specified *solutions planned* and (Total) both AAR leader and unit specified *solutions planned* are the same because each is based upon the same 3 AARs. (Table 3.12, Discussion Focus Factors, and Outputs B-9 and B-10) There were only 3 AARs in which solutions were planned; all of these were specified by the unit during the discussion. The unit leader aiding discussion during the AAR had a very large effect on the number of *solutions planned* (+30). Again, it should be noted that this variable and the attitude of the unit had to be combined because of multicollinearity problems. On the other hand, the interaction variable of participatory feedback and the use of specific BDA had a strong negative effect (-29). This negative effect highlights the fact that the majority of AAR leaders did not perform these actions together. The

large order of magnitudes of the coefficients for these variables indicates that both of these interactions were important to developing solutions.

The number of questions asked by the unit also varied directly with the number of *solutions planned.* This makes sense in terms of the objectives of the AAR – to solve performance problems in order to improve performance. If this objective is reiterated during the AAR, then trainees will focus on it and direct their questions towards its solution/goal. An observation noticed but not measured during data collection, was that the unit seemed to participate in the discussion more when a problem was near solution (as opposed to the problem definition phase).

The most prevalent characteristic of these models seems to be the presence of participatory feedback in each. This is most likely the result of the participatory AARs accounting for a large portion of the *solutions developed* and *planned.* Therefore, the most significant effects are those AAR leader actions that facilitate discussion focus – use of specific BDA, sketches and maps, open-ended and leading questions.

Time

The total time length of each AAR was measured in minutes and then recorded qualitatively. A total of 7 AARs exceeded their CTC time limits. Of the 4 high participation AARs, 2 exceeded the time limits by, respectively, 21 minutes and 9 minutes.[32] Respectively, these AAR leaders spent 90% and 86% of the total AAR time

[32] AAR # 5 and 12.

on discussion. Both of the units and leaders in each AAR were observed to have either a positive or neutral attitude suggesting that, for these cases, time had no bearing on the attitude of the unit or leader. Participants in both AARs were visibly fatigued and, although this was not measured, it was apparent to the observers that participatory comments were less frequent and unit member attention was waning.

AAR Leader and Unit Actions Affecting AAR Length (Time)

In the regression analysis of $\alpha = 0.05$, the percent of total AAR time spent on discussion could not be modeled with AAR leader actions, unit actions, or their interactions. (Appendix B, Regression Analysis, Output B-11) The percent of total AAR time spent on discussion ranged from 24% to 92%. The percentages for the 4 participatory, discussion focused AARs were 52%, 71%, 86%, and 90%. These percentages exemplify the variance of this variable in all 17 AARs. Although it could not be confirmed statistically, it seems that a discussion by a number of people should take longer than a discussion between two people. Therefore, more time should be needed for the articulation and consideration of multiple viewpoints.

Conclusion

Presuming these 17 cases are representative of the CTCs, then the findings of this survey suggest that the majority of AARs conducted at platoon and company level maybe ineffective with respect to discussion participation and focus. If this is true, speculation

of the implications is not pleasant. Most significantly, the AARs that the combat arms units and research and development communities use as models are fundamentally flawed. In particular, R&D has the potential to design AAR support systems that aid non-participatory and unfocused AARs.

A minority of the AARs surveyed could be characterized as both participatory and topic focused. In these, the AAR leaders' actions that affected discussion participation and focus were found to be correlated and interdependent. It is apparent that the synthesis of these actions produces the desired trainee participatory discussion of performance problems and solutions. All of these actions are specified in doctrinal and/or CTC guidance and can be trained in a performance oriented manner.

For these 17 AARs, the use of aids to facilitate discussion participation and focus is limited to specific BDA, the doctrinal performance standards listed in the MTPs, and enlarged sketches and maps. In 2 of the participatory AARs, the AAR leaders had the unit draw their own sketches to explain their statements. In the third participatory AAR, the actual terrain was used as a discussion medium. The last participatory AAR leader used his own sketches in conjunction with the MTP standards to facilitate the discussion and problem solving. The point here is that they all used some type of aid to facilitate discussion of the problem and solution.

Beyond the AAR leader's actions, the unit's command climate and previous AAR experience may affect discussion participation and focus. Additionally, OPFOR participation and use of a 3D terrain model during the discussion could not be measured.

Both of these variables were cited in the AAR research literature as important to discussion participation and focus. To be conclusive, future research must account for these deficiencies.

CHAPTER IV

PROPOSED SOLUTION

"Three-fourths of those things upon which action in War must be calculated, are hidden more or less in the clouds of great uncertainty. Here, then, above all, a fine and penetrating mind is called for, to search out the truth by the tact of its judgment.

An average intellect may, at one time, perhaps hit upon this truth by accident; and extraordinary courage, at another, may compensate for the want of this tact; but in the majority of cases the average result will always bring to light the deficient understanding."

—Carl von Clausewitz
On War, 1830

Review of the Problem

The purpose of the AAR is to improve individual and collective trainee performance. (DA, FM 25-101, 1990, G-1) Trainees can only improve performance if they learn: what was performed correctly/incorrectly, why they performed in that manner, and how to sustain/correct their performance. Thus, an effective AAR is one in which performance problems are identified, defined, and solved in such a manner that the trainees learn the solution – they are able to "adopt a course of action to correct problems." (DA, TC 25-20, 1993, 4-4) Furthermore, the examination of doctrine and review of AAR literature reveals that the AAR has four elements of effectiveness: 1)

discussion participation – trainee participation in the problem solving discussion; 2) discussion focus – focusing the discussion on a single problem and solution; 3) learning reinforcement – mental and physical practice of the solution; and 4) time – timeliness of the AAR after training and timeliness of the learning reinforcement. The first two elements derive directly from AAR doctrine as shown by the doctrinal definition. The AAR is:

> a method of providing feedback to units by involving participants in the training diagnostic process in order to increase and reinforce learning. The AAR leader guides participants in identifying deficiencies and seeking solutions. (DA, FM 25-101, 1990)

Learning reinforcement and timeliness considerations derive from cognitive learning theory. (Chapter II)

Given this description of the AAR, the current training simulation AAR systems were investigated and CTC AARs studied. The result of this work suggests the following multi-faceted problem: *the majority of small unit training system AARs may be ineffective*. The majority of the AARs are not problem solving sessions nor are AAR leaders following doctrinal AAR guidance with respect to discussion participation. Ineffective AARs are occurring at the CTCs and since they are the model for the training and R&D communities, this ineffectiveness may be propagated.

Currently, AAR systems and R&D efforts are focused on making the preparation of the AAR more efficient. The primary focus of STAARS is not the improvement of unit performance, but the collection and networking of standardized data elements from

live, virtual, and constructive training exercises. Although the second draft is incomplete, presentation formats for this data are also standardized by STAARS. (BCTD, 1995) The result of these efforts has been the standardization of the presentation medium for the data.

STAARS, UPAS, CCTT, ATAFS, and STRIPES are committed to a single presentation method. The products required by STAARS and those produced by CCTT, ATAFS, and STRIPES are specifically formatted for one type of media presentation – the television screen or high resolution monitor with sound system. To date, AAR system development has focused on the efficient collection of performance data and the standardized display of that data – in format and medium. This is just one of the system components as shown in Figures 3.1, Conceptual CTC AAR System and 3.2, CTC AAR Components of Chapter III.

A major advantage of simulation training is that a unit can execute multiple simulations of an exercise in a shorter time period and at lower cost than live training allows. Consequently, the unit will conduct multiple AARs – one for each training iteration. Combine this repetition with a single presentation medium, mostly displaying statistical charts and graphs, and the product is trainee boredom. The trainer must be able to highlight the important AAR points in a manner that catches the trainees' attention.

Even with different AAR points, a repeated presentation method will cause the trainee to learn the method, not the presentation content. For example, being shown five statistical reports in the STAARS format will teach a person to differentiate a statistical

report from any other type format. In other words, he can recognize that format. Unless the content of each statistical report was signified, he probably will not remember the five points that were communicated by the statistics. After four AARs in one day of training, trainees will be able to quickly identify the format for a battle summary, battle set, sketch, statistical report, and word slide but will be less likely to remember what the learning points of each were. This is simple pattern recognition and the productions that represent the patterns are being continually reinforced in this situation.

The above conclusion is not as narrow in consideration as it seems. The majority of the CTC AARs surveyed are not participatory discussions involving the trainees. Additionally, the majority of AAR leaders did not allow nor force the trainees to solve their own performance problems. This trainee participation in problem solution is the signifying factor of the standardized information formats and did not occur in 76.5% of AARs observed. Thus, after being lectured to for an hour, four times in a day, the trainees will have learned the information format and perhaps written down some of the AAR leader's points. But few, if any, of the trainees will have articulated the cause and effect factors and elaborated their relationships in terms of what they already know.

A second observation of relying on a single presentation medium is that it does not prompt audience participation; the content signifying effect. The feedback on the screen is perceived as the trainer's, not the trainees.' This is especially true when the presentation medium is controlled by the AAR leader to support the AAR leader's point.

Whether the AAR leader or the AAR system produces the presentation, the trainee still does not perceive the input as his own.

The trainee needs the ability to input into the presentation to make the feedback "his own." Trainees are much more likely to correct a problem for which *they* have identified and developed a solution for. With the current AAR systems, the trainer is left to soliciting discussion from the audience with verbal statements and the pre-designated AAR products.

To stimulate audience participation, the CTCs use white boards, enlarged sketches or maps combined with participation feedback and open-ended and leading questioning techniques. Many combat arms trainees below battalion level do not have the ability to verbally communicate clearly. Subject matter experience has shown that drawing a picture/sketch or moving an object on a terrain model often helps soldiers articulate their point. Additionally, the physical action encourages participation in the discussion. It follows then, that accurate 3-D terrain boards would also be good tools to prompt physical participation and focused discussion. These additional discussion aids, with the exception of the large TV screen, need the attention of R & D in order to make them more responsive to the trainee during discussion.

There is little doubt that AAR systems are being developed to produce the relevant performance data to support focused discussion points. But the systems are not flexible enough to aid the participants in self critique. In other words, AAR systems need the capability to allow the *participants* to identify the AAR points and then produce the

relevant performance data that it has recorded. This would empower the unit leaders by giving them control of the AAR. In turn, this empowerment would reinforce the leader's responsibility to supervise corrective training to standard; thus, improving performance.

For most actions at the platoon and company levels, the combination of word slides with AAR focus points, a video with audio replay of each participant's action, an accurate 3-D terrain model, and a white/chalk board are the tools necessary to create the best conditions for the trainees to assimilate the feedback. Yet none of the AAR systems consider the combination of products and/or more than one presentation medium. The trainer using STAARS is allowed a choice of formats for 4 of the 101 AAR products. (BCTD, 1995) To design a *complete* AAR system, multiple presentation methods must be integrated with the standardized product formats. An AAR system should be designed to integrate multimedia presentation techniques (TV screen with sound system, 3-D terrain model, and chalk board) and leverage new presentation technologies (holographic replay, voice-to-text recording, etc.).

Notwithstanding these potentials for technological improvement, the process that these improvements would support must be sound. A lesson of project and organizational engineering over the past 20 years is that technological advances or improvements do not solve problems rooted in a flawed process. Multiple examples of this can be found in organizations that adopted the computer or some form of automation as a solution to problems in organizational structure, strategic planning, and leadership.

(Kerzner, 1995, 56, 161, 431, and 647) The basic process must be effective before it can be made more efficient.

The majority of CTC AARs surveyed were ineffective because AAR leaders did not focus discussion on solving a performance problem completely nor did they prompt, monitor, and encourage trainee participation to do so. The AAR at the CTCs is primarily a lecture presentation of OC observations and recommendations with little trainee input. These are procedural deficiencies that standardized information formats will not solve.

By imitation or support of CTC AAR systems, small unit simulation training systems seek to improve an ineffective process. None of the systems – STAARS, UPAS, CCTT, ATAFS, and STRIPES – integrate a terrain model, trainee drawn sketch, or other discussion media into the AAR. (Appendix C, Current AAR Systems in Training Simulations) ATAFS has the potential to benefit the AAR leader the most with the automated output of pre-designated questions. But this increases the AAR leader's input and articulation, not the trainees.' As currently designed, small unit simulation training AAR support systems are inadequate and incomplete for the purpose of conducting an effective AAR. AAR system designs must consider the trainees and what the AAR leader needs to get them to participate in a discussion of training performance. The problem to solve concerns what the trainee needs in order to learn from his performance. An AAR is not effective if the trainees do not learn. The approach outlined in this chapter offers a solution to increase the trainees' learning efficiency.

Simulation training AAR systems are actually a single component of the AAR process that support the efficient collection and presentation of performance data. However, the functionality of these AAR systems stops with the display of performance data. These systems are not capable of:

- Prompting trainee participation in a problem solving discussion;
- Supporting trainee elaboration;
- Supporting retraining to reinforce learning points.

Notwithstanding, what these simulation support systems *are* capable of is absolutely critical to the AAR process. These systems provide what Marshall sought on the battlefields of Europe, the South Pacific, and Vietnam – ground truth. If performance is not improved with respect to what actually happened, then mistakes are likely to be repeated in the absence of blind luck.

The proposed solution to the above problem entails: 1) implementing a meta-cognitive instructional theory to guide a collaborative discussion focused on solving performance problems; 2) using interactive discussion mediums that support trainee elaboration and discussion (of the problem and solutions); 3) using simulation technology to reinforce the learning point (solution to the problem); and 4) using simulation technology to ensure the timely conduct of the AAR and learning reinforcement exercises.

The novelty of this approach lies in the detailed analysis of effectiveness in the AAR and the extension of the AAR process to encompass re-training.[33] Simulation training systems and AAR subsystems have allowed three of the elements of effectiveness (discussion focus, learning reinforcement, and timeliness) to be realized. A proposed design concept based upon this approach is presented in Appendix E, Proposed Design.

The proposed AAR approach implements Allan Collins' Inquiry theory to increase the effectiveness and efficiency of the trainees' learning.[34] (Collins & Stevens, 1983) This instructional strategy increases learning effectiveness by requiring participants to fully explain what happened, why it happened, and how to perform the task(s) better. None of these elements are allowed to be ignored. Learning efficiency is increased by guiding the participants to discuss only the cause and effect relationships that determine the performance outcome. This guidance is logically structured and closely resembles the scientific method – systematically formulating and testing multiple hypotheses. Extraneous and distracting subjects are avoided through the theory's structured approach to problem solving.

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[33] The term "retraining" denotes the training that occurs after a training exercise to correct deficiencies uncovered during the exercise and AAR.

[34] Learning effectiveness and efficiency are covered in Chapter II, 45, 54 and 55.

Inquiry Theory

Allan Collins, a leading scientist in the fields of cognitive science and human semantic processing, developed an instructional theory that is labeled inquiry teaching. (Collins & Stevens, 1983, 247 to 248) Collins inductively developed this theory by observing a number of expert teachers, cataloging the instructional strategies they used to teach concepts and ideas in differing situations, and developing heuristics for the application of each strategy. (Collins, 1987, 181) With the aim of teaching students how to solve problems more efficiently and effectively, Inquiry theory is ideal for knowledge acquisition. The theory has two overarching goals: to teach students 1) how a specific rule or theory is applied, and 2) how to derive a rule or theory. (Collins & Stevens, 1983, 249)

Inquiry theory fits knowledge domains with causal relationship structures. This is demonstrated by the wide variety of subject domains Collins' subjects were teaching when the data for this theory was gathered. These disciplines were: arithmetic, art history, law, medicine, geography, moral education, botany, and computer science. (Collins & Stevens, 1983, 251 to 257) In art history, the problem spaces that are examined are pictures and sculptures. The causes and effect are separated. Painting techniques and different of parts of the painting interrelate to produce the effect, in this case, on the viewer. Another example can be shown with medicine. The problem spaces, or "cases" as Collins calls them, are medical cases. The symptoms, history, and course of

symptoms are the factors that combine to cause a disease – the effect. (Collins & Stevens, 1983, 254)

Inquiry theory fits well in the domain of Army doctrine and AARs. Essentially, the AAR is founded in doctrine – which is a set of principles and application rules (for those principles). During training, the trainee applies these principles to different situations. The key to training performance diagnosis is to discover the cause, or combination of causes, of a specific performance output. Hence, the cases (problem spaces) that must be diagnosed are missions, situational training exercises, or a phase of mission execution. The effect is the performance output or result identified as undesirable. These are judged undesirable with respect to the performance standards outlined in the mission training plan (MTP) references or the unit's organizational procedures, objectives, and goals. The causes of the effect are: 1) the lower order supporting MTP subtasks and performance requirements, and 2) the unit's analysis and actions with respect to the mission, enemy, terrain, troops, and time conditions. The Inquiry approach efficiently and systematically leads the analyst through the great number of potential causes and combinations of causes to identify those that specifically affected the outcome.

Inquiry Theory Components

Inquiry theory has three components. These components are: the goals and subgoals of the teacher, the dialogue strategies teachers use to achieve the goals, and the

control structure the teacher uses to allocate time pursuing different goals and subgoals. (Collins & Stevens, 1983, 257, 260, and 274)

It is helpful to understand the causal structure notation that Collins uses before tackling the theory. Collins represents causal dependencies in terms of variables/factors, rules, and theories. (Collins & Stevens, 1983, 251 to 253) The factors are categorized as dependent and independent variables. Whether a variable is classified as dependent or independent depends upon the goal/subgoal of the teacher without respect to the direction of causality between the variables. The dependent variable is "what one tries to make predictions about in the real world." (Collins & Stevens, 1983, 255)

Given a set of factors and a dependent variable, a rule describes the conditional relationship of one or more factor values to dependent variable values. (Collins & Stevens, 1983, 252) A rule's utility or value is judged on how well it accounts for the independent variables that affect the dependent variable value range. In turn, a theory specifies the causal structure of interrelated rules. (Collins & Stevens, 1983, 252) The theory's utility is judged on the number of situations in which it can be successfully applied to a specific problem domain.

Graphically, the factor relationships that correspond to a rule or theory can be shown as a task tree or *and/or graph*. Figure 4.1, Control Organic Fires (next page), depicts the factor relationships for that leader task. This task supports any collective task (*Assault* or *Overwatch/Support by Fire* for example) that requires an enemy to be engaged with direct fire weapons. (DA, ARTEP 7-8-MTP, 1994)

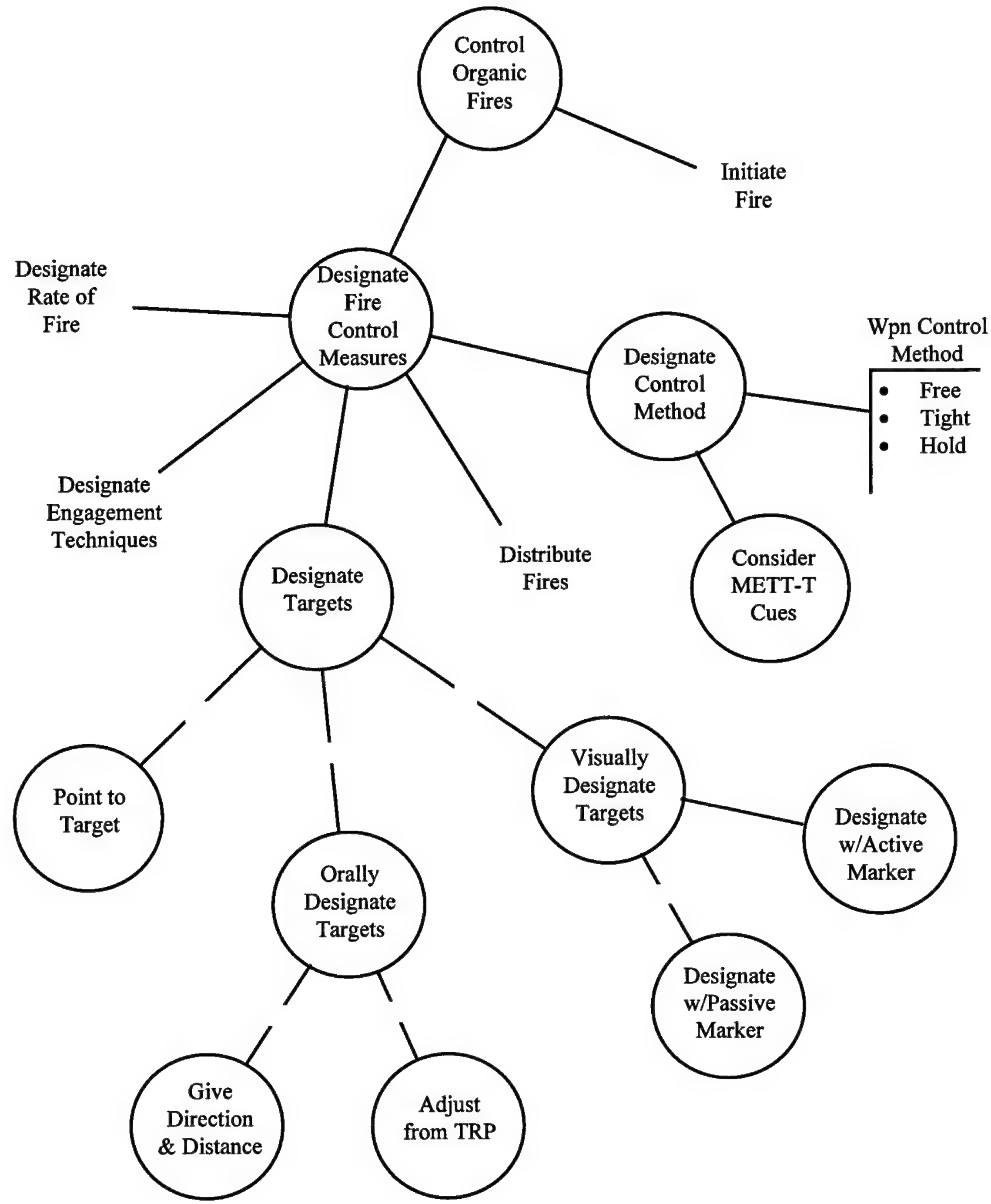

Figure 4.1, Control Organic Fires

Note: AND/OR Graph for Control Organic Fires

AND = "________" OR = "____ ____"

Un-circled subtasks are not expanded.

Goals and Subgoals

As stated before, the two top-level goals of inquiry teaching are to teach the student 1) specific rules/theories, and 2) how to derive rules/theories. (Collins & Stevens, 1983, 257) Collins associates two subgoals with the first top-level goal and four subgoals with the second. These subgoals are the intermediate objectives that must be achieved in order to satisfy the top-level goals. They are not comprehensive, but represent the subgoals that were most frequently employed by the expert teachers Collins researched. (Collins & Stevens, 1983, 258)

The subgoals that support the teaching of a specific rule/theory are: 1) the *debugging of incorrect hypotheses,* and 2) the teaching of *how to make novel predictions based upon a specific rule/theory.* The student must learn to analyze a hypothesis to determine if it is correct or incorrect and, if incorrect, identify the false assumption, premise, or factor. This debugging is critical in preventing students from forming misconceptions about the application of the rule/theory. (Collins & Stevens, 1983, 258)

The second subgoal, learning *how to make novel predictions with a rule/theory,* follows from the first. Simply, this subgoal requires the student to know how to properly apply the rule/theory to a unique set of conditions and accurately predict an outcome. (Collins & Stevens, 1983, 258) This requires the student to fully understand the factors, interrelationships, and overall structure of the rule/theory. They must apply the rule/theory purportedly learned.

The four subgoals associated with learning how to derive a rule/theory are learning: 1) *what questions to ask in order to derive the* (factors and assumptions of the) *rule/theory*, 2) *what form a rule/theory should take*, 3) *how to evaluate a rule/theory just constructed*, and 4) *how to verbalize and defend the rule/theory just constructed.* (Collins & Stevens, 1983, 259) Many of these subgoals depend upon the previous set of subgoals – the abilities to debug incorrect rules/theories and apply rules/theories to make a prediction.

Learning *what questions to ask in order to derive a new rule/theory* and *what form* (cause and effect structure) *a rule/theory should take* go hand in hand. To meet these two subgoals, there are three basic questions that the student needs to answer, irrespective of subject domain. In order, these are:

1. What is the dependent variable that the rule/theory must describe?
2. What are the factors that affect the dependent variable?
3. How do these factors relate to each other to affect the dependent variable?

The second question should be repeated for the (just identified) factors that affect the dependent variable so that, through multiple iterations, most of the important factors are identified. Answering these questions in this sequence will aid the student in describing the causal relationship structure of the rule/theory.

Learning *how to evaluate a freshly constructed rule/theory* is dependent upon the domain specific, evaluation criteria. (Collins & Stevens, 1983, 259) For performance analysis in the AAR environment, trainees may use logic/common sense, doctrinal

principles and training standards, past experiences of individuals, and/or simulations to apply the rule/theory to a new set of battlefield conditions (METT-T). This step is critical in defining which conditions the rule/theory is operable in. A key characteristic that soldiers must realize is that the derived rule/theory is not a stand-alone principle, but a condition specific phenomenon. The mission, enemy, terrain, troops, and time conditions dictate the utility of the rule/theory. The variations of each of these conditions affect the dependent and independent variables; thus making the combat performance domain extremely complex.

The last subgoal, teaching the student *how to verbalize and defend a rule/theory*, is critical to learning and achieving a common mental model among a group. (Chapter II) The verbalization of the reasoning behind a rule/theory causes the student to articulate and elaborate the important factor relationships and conditions that affect the dependent variable. The elaboration is a form of practice that constructs and reinforces production rules. (Anderson, 1993) In the production system theory of cognition (Anderson, 1993), knowledge and skill are represented by production rules (condition-action pairs) and chunks (groups of production rules). Elaboration plays a major role in strengthening the connection between and within productions and chunks. (Williams, 1996a) This connection strength determines what one knows and is able to recall for use. (Anderson, 1993) Without the connection, the student cannot know and/or apply the rule/theory. Thus, what you learn is based upon what you can relate to previous experience; given that

previous experience consists of knowledge that exists as productions and chunks in procedural and declarative memory. (Appendix A, Theoretical Foundations)

The oral defense of the rule/theory in the face of criticism motivates the student to articulate and elaborate his reasoning as competently as possible, a natural result of perceived peer pressure. To prompt this subgoal, Collins recommends requiring each student to either articulate and elaborate the reasoning for his own rule/theory or support or criticize the reasoning of another. (Collins & Stevens, 1983, 259) This discussion results in the rule/theory being understood by the group. They then share a common understanding of the subject matter and can collectively work to improve performance in this context.

Strategies

Given these goals, the teacher constantly assesses and diagnoses each student's domain knowledge with respect to his line of reasoning. The teacher selects one of 10 strategies with which to engage the student in order to achieve one of the two goals stated above. The strategy selection is based upon what the student is trying to learn (goal or subgoal), what he knows and does not know, and his misconceptions about how rules/theories are formed and applied. (Collins & Stevens, 1983, 251 to 257, and Collins, 1987, 183 and 195 to 198) However, all of these techniques force the student to elaborate and, thus, learn.

Collins outlines 10 strategies that are commonly used by expert teachers to teach students.

1. *Selecting positive and negative exemplars* is used to demonstrate the relationship between relevant factors in a concept, rule, or theory. The chosen examples are often positive or negative paradigm cases for that concept, rule, or theory in that all the major factors consistently lead to a conclusion that is in line with the concept, rule, or theory. (Collins & Stevens, 1983, 260, and Collins, 1987, 183)

Collins illustrates this strategy for teaching what geographical factors affect rainfall. As positive exemplars demonstrating factors that lead to heavy rainfall, the cases of the Amazon, Oregon, and Ireland are examined. The negative exemplars that demonstrate factors that cause little rainfall are southern California, northern Africa, and northern Chile. Once the students understand the factor relationships of rainfall, the teacher covers more complex factor interactions that affect rainfall in areas such as the eastern United States or China. (Collins & Stevens, 1983, 260 to 261)

This strategy can be used to illustrate the terrain factors that impact on effectively suppressing an enemy position from a support by fire position.[35] Examples of support by fire positions with cover and concealment can be compared to positions without cover and concealment. In this example, the trainees should be able to discern what constitutes cover and concealment for the task given a specific terrain type.

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[35] An enemy position, aka an "objective", is an enemy unit (group) occupying a specific area of ground (terrain). Thus an enemy position actually consists of a number of positions with individual or pairs of individuals.

2. *Varying cases systematically* is a strategy that is used to highlight various interactions between a dependent variable and different factors of a concept, rule, or theory. The systematic sequence of example variation can emphasize how a particular factor relates to changing conditions and factors or a combination of factors. (Collins & Stevens, 1983, 262, and Collins, 1987, 183 to 184)

Collins gives an example of this strategy for teaching a student about the properties of light rays shining through a lens. Given a light source and a lens, the distance between the lens and the light source can be systematically varied to demonstrate how light rays cross over, come to a focal point, and diverge. (as they travel from the source, through a lens, to a reflecting object). (Collins, 1987, 183 to 184)

Using the same support by fire position example, different cover and concealment combinations may be used to highlight the affect on communication within the friendly element The ease of communication amongst the element varies inversely with the amount of cover and concealment the unit takes/assumes. Consequently, the realization of this relationship impacts on how the element's fires are controlled and distributed.[36] Here the AAR leader must show an example of the unit in a support position with good observation and fields of fire. The number and location of enemy hit/missed and number and type of rounds fired at each enemy position are the required BDA. In the absence of fire control measures, big and close targets located in the middle of the engagement area

[36] Fires (noun) is the act and effect of firing a weapon(s).

are usually hit first. This forces the trainees to reform the rule for effective suppression of an enemy to include fire control.

3. *Selecting counterexamples* strategy is used when a student forms an incomplete or incorrect hypothesis about the concept, rule, or theory. In this case, the teacher selects an example that satisfies the student's misconception but violates the actual concept, rule, or theory. (Collins & Stevens, 1983, 263 to 264, and Collins, 1987, 184) Reigeluth, the editor of Collins (1987), points out that this strategy is likely to contribute to deep cognitive processing (understanding) of the concept, rule, or theory. (Reigeluth, 1987, 184) However, he does not explain why this is so.

Collins demonstrates this strategy with a student who may incorrectly believe that a magnifying glass always makes objects such as letters printed on a sheet of paper larger. To counter this hypothesis, the teacher may move the magnifying glass to a point that is halfway between the print and the student's eye and demonstrate otherwise to him. (Collins, 1987, 184)

A supporting element may ignore the requirement for fire control measures and equate good observation and fields of fire with effective suppression of an enemy position.[37] In this case, the counterexample must show enemy positions not being effectively suppressed when observation and fields or fire are present.

4. *Generating hypothetical cases* is used to force students to reason about an aspect of a concept, rule, or theory and generalize this aspect to differing situations. This

strategy is similar to the strategy of producing counterexamples since its aim is to test the student's knowledge of and ability to apply the concept, rule, or theory. (Collins & Stevens, 1983, 264 and 265, and Collins, 1987, 184)

Collins demonstrates this strategy by challenging a geography student's ability to determine why a specific area, such as Louisiana, would support rice cultivation. He does this by supposing how rice might grow in Louisiana without the rainfall.

For this strategy the AAR leader can challenge the trainees to explain how they would alter fire control methods to achieve effective suppression of an enemy in differing situations. Some examples of differing situations are:

- Given an enemy unit occupying hasty positions; in sparsely wooded, flat terrain; in daylight with unaided observation ≤ 100 meters and restricted by ground vegetation.
- Given an enemy unit occupying hasty positions; in rocky, mountainous terrain; in daylight with unaided observation ≤ 1000 meters and not restricted by ground vegetation.
- Given an enemy unit occupying prepared positions; in sparsely wooded, rolling terrain; in limited visibility with unaided observation ≤ 25 meters, restricted by ground vegetation, and 50% lunar illumination.

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[37] The performance standard for "effective suppression" is defined as the platoon engaging at least 50% of the enemy position *and* destroying or forcing the withdrawl of 100% of enemy in an assigned engagement area. (DA, ARTEP 7-8-MTP, 1988, 5-9)

This forces the trainees to articulate how fire control measures are affected by specific terrain and weather factors. It is not enough for a trainee to simply list the capabilities of his equipment and weapons, he must understand: 1) how to apply those capabilities and 2) which capability is maximally effective in a situation.

5. *Forming hypotheses* is the most prevalent strategy used by teachers. They get students to formulate general rules about different factors in relation to various values of a dependent variable. (Collins & Stevens, 1983, 265, and Collins, 1987, 184) This strategy is aimed at Collins' second goal – getting students to derive their own rule or theory given some evidence. (Editor of Collins, 1987, 184)

Collins illustrates this strategy with a teacher asking a student to formulate a set of rules that describe what focal length is dependent upon. The student hypothesizes that the curvature of a lens inversely affects focal length; i.e., the greater the curvature, the less the focal length. (Collins, 1987, 184)

The AAR leader can ask trainees to hypothesize rules to determine when a specific type of marking signal should be used to control the organic fires of the unit. Marking signals can generally be categorized as visual, aural, and tactile signals to mark enemy, friendly, or target reference point positions.[38]

6. *Testing hypotheses* is a strategy in which the teacher tries to get the student to systematically test a hypothesis. Essentially, the student must learn to identify the different variables and then test a dependent variable while holding all the other variables

[38] A target reference point (TRP) is any point that is known to the unit.

constant. (Collins & Stevens, 1983, 267 to 268, and Collins, 1987, 184) This is an extension of the teacher varying cases systematically, the second strategy, which serves as an example for the student.

Collins demonstrates this strategy with a continuation of the example used in forming a hypothesis above. After the student formulates his hypothesis about what factor(s) affect focal length, the teacher asks him how the hypothesis can be tested. The point is to make the student derive the requirements that will lead to a sound test of the hypothesized factor, in this case, the curvature of the lens. The control of different variables and testing of special cases are examples of the requirements the student must account for. (Collins & Stevens, 1983, 267, and Collins, 1987, 184)

After the trainee has formulated a general rule for employing marking signals, the AAR leader asks him to give an example of how he could have employed the rule in the training exercise the AAR is examining. The key is to force the trainee to articulate the factors (that were present) that should have been considered.

7. *Considering alternative predictions* is a strategy in which the teacher encourages the student to consider different alternative values of a dependent variable. The teacher is trying to get the student to consider how the values of the known factors relate to other possible dependent variable values. (Collins & Stevens, 1983, 268) This fosters differential diagnosis or comparative hypothesis testing as a learning strategy. (Collins & Stevens, 1983, 269, and Collins, 1987, 184)

"For example, if a student thinks that an image turns upside down as one moves a lens toward one's eye, the tutor might ask the student to consider whether instead it might turn the image right side up." (Collins, 1987, 184)

To encourage the trainees to consider alternative predictions, the AAR leader may ask if it might be better to mark a TRP rather than a friendly position in order to orient friendly fires on to an enemy. Another possibility is to ask the trainees to describe what their actions should look like from the enemy position and consider how this perspective affects the hypothesized rule.

8. *Entrapping students* is a strategy in which the teacher offers incorrect hypotheses in order to get students to reveal their underlying misconceptions. Here the teacher is taking the student's reasoning and turning it into a general rule and then offering a counterexample on which to test the rule. The carefully chosen counterexample can reveal faulty reasoning based upon unnecessary or insufficient factors, and incorrect factor relationship interpretation. This leads the student to learn more complex relationships, after positive and negative exemplars are established, and understand the subject matter more deeply. (Collins & Stevens, 1983, 270 to 271, and Collins, 1987, 185)

Collins demonstrates this strategy with a student who is incorrectly using the equatorial latitude as the only factor to predict surface temperature. Collins chooses a counterexample of equatorial Peru. At this location, the temperature is much cooler than was induced because of an ocean current. (Collins & Stevens, 1983, 270)

For trainees who incorrectly assume that they should never mark the friendly unit, the AAR leader could entrap them by giving them a situation in which different people in the element can see different parts of the enemy, but none can see the whole objective. Adding an assault element (that the overwatch element is supporting) and TRP's that cannot be designated or seen by all of the overwatching element, the tactical solution is to mark the friendly assault element and adjust the suppressive fires from them.

9. *Tracing consequences to a contradiction* is a strategy the teacher uses to get the student to correct his misconceptions. Given a student's incorrect belief, the teacher traces the consequences of the misconception to a conclusion that is plainly incorrect. This is a form of immediate feedback given on the practice of formulating hypotheses (Reigeluth, 1983, 271) and forces the student to consider the implications of his predictions on all of the factors. Hence, they build consistent theories and learn to debug these theories. (Collins & Stevens, 1983, 271 to 273, and Collins, 1987, 185)

Collins demonstrates this strategy with a student that has incorrectly ascertained that evaporation from the Amazon River is responsible for the heavy rainfall in the region. In fact, evaporation from the ocean is the largest factor of heavy rainfall. Collins points this out with the following questions: "1) Does most of the water in the river evaporate or flow into the ocean? 2) If most of the water flows into the ocean, won't the process soon dry up?" The student is then forced to realize that evaporation from the ocean is responsible for the heavy rainfall in the Amazon region. (Collins & Stevens, 1983, 273)

Again, given a unit that believes that visually marking the enemy is the only fire control marking method they need, the AAR leader may ask them how they know where to shoot if they cannot see the marker. He can then ask them if they will move (and expose themselves) or not shoot at all? The trainees should then realize that they must choose one of the following methods: mark a TRP (to reference and adjust from), mark the friendly assault element as a no fire zone, or employ a combination of marking signals.

10. *Questioning authority* is a strategy in which the teachers try to make the students self-reliant in constructing their own theories and conclusions and not relying on the teacher or a generalized book solution. Here, the teacher feigns ignorance or simply refuses to give the student an answer. This is an important strategy in motivating hypothesis formulation and testing and influencing the student to question assumptions and facts that appear to be givens (Collins & Stevens, 1983, 273 to 274, and Collins, 1987, 185)

Collins demonstrates this strategy with a student who asks whether a lens that is more curved has a shorter focal length than a lens that is less curved. In this case, the teacher can ask how the student can construct an experiment to find out for himself and then tell him to do it. (Collins, 1987, 185)

This should be a well used strategy for AAR leaders to prompt participation. He can accomplish this by feigning ignorance or refusing to solve *their* problem. Whichever the AAR leader chooses, the trainees must be required to solve the problem.

All ten of these strategies are based upon the teacher: 1) knowing the body of knowledge (subject matter) that must be taught – having a lesson plan, and 2) having a good deal of classroom time to pursue these strategies. The AAR leader–trainee relationship is not a classic, teacher–student relationship. There are a number of differences between the classic teacher–student instruction and the AAR leader–trainee, not least of which are the basic assumptions of each.

A second difference lies in the AAR leader's role and authority. A tutor's response to a student's impasse intends to focus the student back to the supposed correct path of learning. (Chan and Baskin, 1990, 8) But in AAR cases, the leader may not always know the correct paths or have the authority to impose a correct solution. Unit leaders, who have the authority to implement the correct solution, are often inexperienced and/or immature. CTC OCs with an expanded experience base are more likely to have a correct (or improved) solution, but lack the authority to implement it. An additional problem that could complicate the OCs role as an AAR leader is the unit is too inexperienced to realize the full implications of the feedback. (Chapter II, 40, SHERIKON, 1996, Anderson, 1993, Newell, 1992)

Dialogue Control Structure

The control structure consists of four basic parts: 1) a set of strategies for selecting cases with respect to the top-level goals; 2) the student model of what he knows, does not know, and misunderstands; 3) the agenda of goals and subgoals; and 4) a set of

priority rules for adding/deleting goals and subgoals to/from the agenda. (Collins & Stevens, 1983, 274) Overall, these parts collectively form the heuristics that the teacher must learn in order to help the students achieve the top level goals.

The case selection strategies are a set of criteria to select a single or set of cases (examples) to optimize the student's ability to master the top-level goals and subgoals. (Collins & Stevens, 1983, 274) The first is *selecting cases that illustrate more important factors before less important factors*. Obviously, this places emphasis on the basic factors that define the rule/theory. *Selecting positive and negative exemplars* and *varying cases systematically* are strategies most often used in these cases. (Collins & Stevens, 1983, 260 to 261, and 274)

The second selection criteria is *select cases to move from concrete to abstract factors*. (Collins & Stevens, 1983, 274) Students learn more efficiently if the factors under discussion can be related to experience. (Anderson, 1993) Abstract factors require the student to generalize his experience and take longer to learn. (Collins & Stevens, 1983, 274)

The third case selection criteria is *select more important or more frequent cases before less important or less frequent cases*. (Collins & Stevens, 1983, 274) Collins observed that, other criteria being equal, the expert inquiry teacher will select cases that are more familiar to the student or occur most often. (Collins & Stevens, 1983, 274)

The AAR leader can use the case selection strategies to guide the preparation of the AAR. The AARs first responsibility is to identify the problem (spaces) that the

discussion will be focused on. For homestation training where the AAR leader is a unit leader, the problem spaces will be defined by the training objectives of the unit. The unit's training objectives should have associated and specific performance standards. The standards that were not attained define the problems that require a solution. For CTC (or EXEVAL) AAR leaders who are unfamiliar with the trainees' strengths and weaknesses, this is difficult. Those AAR leaders must consider the rotational guidance issued by their higher headquarters and their subjective assessment of the unit's training proficiency level.

Once the problems are identified, the AAR leader selects examples (cases) in accordance with the selection criteria outlined above. Current simulation training system AAR components (Appendix C, Current AAR Systems in Training Simulations) are being designed to support the selection and presentation of these examples. The AAR leaders without the benefit of simulation system support, must rely on hand drawn sketches, scaled terrain models, and enlarged maps to implement the strategies and facilitate trainee elaboration and discussion.

The second component of the control structure is the creation of a student model. The student model is constructed from what the teacher expects the student to know and the student's performance during the session dialogue. As the teacher questions the students about the values and relationships of independent and dependent variables, he notes the factors the student knows/does not know and the misconceptions of factors and their relationships. (Collins & Stevens, 1983, 275) The critical function of the student

model is to identify "bugs" in the student's reasoning. "Bugs" are errors or omissions in the students' reasoning that prevent him from learning a rule/theory or how to derive a rule/theory.

In an independent analysis, Littman et al. (1990) statistically verified Collins' strategies to identify student bugs. Their study of 11 experienced, collegiate tutors identified the four most common strategies used. In order, they were: 1) *generating hypothetical cases*, 2) *forming hypotheses*, 3) *testing hypotheses*, and 4) *questioning authority*. The *questioning authority* strategy was employed for a secondary purpose also – to allow/require students to practice their problem solving skills. (Littman et al., 1990)

The AAR leader's construction of the student model is his assessment of the unit's knowledge and proficiency level. This assessment is done during the AAR discussion. However, the AAR leader constructs this assessment with respect to doctrine. In other words, he must be well versed in the doctrine associated with the problem in order to realize what the unit does/does not know and be able to identify faulty reasoning. A soldier given the responsibility to conduct an AAR has the responsibility to be prepared (DA, 25-101, 1990, and TC 25-20, 1993), just as a professor must prepare for course instruction. How thoroughly the AAR leader prepares himself will dictate how well he will be able to diagnose bugs.

The last two components of the control structure are the agenda and set of conflict resolution rules for adding/deleting goals to/from the agenda. These goals and subgoals

are the same ones explained earlier in this chapter. The priority for adding subgoals to the agenda depends upon the type of bug that is identified. These priorities are:

1. Add subgoals to correct errors before omissions. Collins found that errors in reasoning had a greater and far reaching affect on the students' subsequent reasoning than did the omission of a factor. (Collins & Stevens, 1983, 275)

2. Add subgoals to correct prior steps before later steps. Barring a sequence determined by the students' responses, the subgoals should seek to correct deficiencies in a rational (logical) order. (Collins & Stevens, 1983, 275)

3. Add subgoals to correct shorter fixes before longer fixes. Shorter fixes are prioritized over longer fixes because they are easier to complete. (Collins & Stevens, 1983, 275)

4. Add subgoals that pertain to more important factors before less important factors. Obviously, more important factors have a greater effect on the dependent variable which makes their interrelationships a higher priority to learn. (Collins & Stevens, 1983, 275)

Collins' method for dealing with multiple bugs is simple. Given multiple bugs in the student's reasoning, the teacher always selects the highest priority bug to fix. Once this bug is corrected, he chooses the next highest priority bug. If, in the midst of a dialogue (questioning strategy), the teacher diagnoses a higher priority bug, he interrupts (changes the subgoal and selects a new strategy) to correct that bug. (Collins & Stevens, 1983, 276) However, Collins does not give any guidance on prioritizing bugs between

multiple students. In this case, it seems that the students themselves could help diagnose and correct bugs between themselves and defer to the teacher at impasses.

Is Inquiry Theory Effective?

There are two remarkable demonstrations of the effect that Inquiry theory has on learning; Valerie J. Shute's and Robert Glaser's *Smithtown* (Shute and Glaser, 1990) and Alan Lesgold's, Gary Eggan's, Sandra Katz's, and Govinda Rao's *Sherlock* (Towne & Munro, 1991, and Lesgold et al., 1992) Both of these are simulation-based systems designed to use inquiry strategies for domain specific knowledge acquisition. Each found that inquiry skills dramatically increased the student's ability to remember and apply the domain knowledge. These systems are covered in more detail in Appendix D, Implementations of Inquiry Theory.

<u>Smithtown</u>

Smithtown is an intelligent tutoring system that systematically guides the student's discovery of microeconomics. The system has two goals. The first is to aid the student in mastering scientific inquiry skills – becoming more systematic and goal oriented in the discovery of rules and theories. The second is to impart microeconomics subject content to the student. (Shute and Glaser, 1990, 51 to 53) Shute and Glaser found that the "most optimum learner behaviors … are systematic, hypothesis-driven activities." (Shute and Glaser, 1990, 74) In other words, the students who learned the most, as measured by pretest – posttest change, about microeconomics learned and

applied inquiry skills. Relative to the pretest, those who did poorly on the posttest resisted the guidance of the intelligent tutor in Smithtown or were in the control group that did not use Smithtown. (Shute and Glaser, 1990, 63)

Shute and Glaser identified and addressed two problems when developing the instruction tutor for induction reasoning and hypothesis testing. These problems are that "many learners can induce regularities/patterns but do not treat them as hypotheses to be tested" and when they do test a hypothesis, many use faulty methods or procedures that do not guarantee reasonable or relevant conclusions. (Shute and Glaser, 1990, 52) These problems were the impetus for the goal to teach effective inquiry skills.

Smithtown is remarkable for instruction efficiency. The performance difference between students instructed by Smithtown for 5 hours and students instructed by university economics professors for 11 hours were not statistically significant. (Shute and Glaser, 1990, 67 and 73) With less than half the instruction time, students using Smithtown performed just as well as students in an undergraduate economics course on the same tests.

Sherlock

With Sherlock, Lesgold et al. (1992) establish a coached practice environment to train diagnosis and repair of the F-15 Manual Avionics Test Station. The test station itself is used to diagnose failures of navigational equipment on the F-15 aircraft. However, when the test station fails, it must be diagnosed and repaired by a human

technician. The system's goal is the development and refinement of mental models to enhance the student's problem solving and inductive learning skills. (Lesgold et al., 1992, 51, and Towne & Munro, 1991, 328)

Sherlock's intelligent tutor coaches the student's problem-solving performance, assesses student strengths and weaknesses through model tracing, and assigns progression problems based upon the assessments. (Lesgold et al., 1992, 51) An analysis of this system reveals that the problem solving strategies are an adaptation of Inquiry theory. The students that train with Sherlock have a basic working knowledge of electrical circuitry. Thus, the students are not novices and know most of the factors that may cause, or combine to cause, a system failure. Sherlock teaches the student to efficiently find and diagnose the failure. In terms of Collins' Inquiry theory, it accomplishes this by requiring the student to *form a hypothesis* about the location of the failure, *test the hypothesis*, and repeat the steps until the location is determined. The student can consult the tutor to debug his hypothesis by *tracing consequences to a contradiction*, *considering alternative predictions*, *varying cases systematically*, and establishing (*selecting*) *positive and negative exemplars*. Lesgold et al. refer to this interaction with the tutor as "reflective follow-up." (Lesgold et al., 1992, 57 through 58) This process is repeated for diagnosing the cause of circuit failure once the location is determined. By employing Inquiry strategies, the student is able to realize the factors that indicate the location and nature of a failure in the test station.

Lesgold et al. have developed a second generation system, Sherlock II, that has not been tested with students. However, the first version, Sherlock, has been tested for its effect on learning. The effect Sherlock had on training was determined by measuring pretest–posttest change and is even more remarkable than that of Smithtown. Lesgold et al. found that 20 to 25 hours of Sherlock practice time produced average performance improvements that were commensurate with the effects of 4 years job experience. (Lesgold et al., 1992, 54) While these results seem incredible, the learning gain from Sherlock's approach was independently verified with 32 college students. Johnson et al. (1993) found that the tutorial group showed a 78% improvement (in actual troubleshooting success) over the control group.

Although testing a large number of circuit boards seems like a mundane, time consuming task, it is a relevant example for an AAR. The location and correction of faults in the test set requires the knowledge of a number of different factors and their relationships. While the actual testing methods (using an oscilloscope or multimeter) are simple tasks, the student must: 1) consider what the test station was trying to do when it failed; 2) develop a mental representation of the circuitry involved in the failed function; and 3) develop a plan for testing that functional circuit. Otherwise, the student is left searching tens of thousands of parts for the fault. (Lesgold et al., 1992, 51 and 52) Essentially, the student must learn the cause and effect relationships between components and the troubleshooting methodology used by the system to narrow the choices for the fault location. Then, the student must develop an efficient circuit test plan to verify his

hypothesis. The better he understands the factor relationships, the sooner he will isolate and correct the problem.

Like the airmen trained on Sherlock, AAR participants have different levels of expertise with differing levels of realization about factor relationships. Collectively, the unit is not at the novice level. What Sherlock has shown is that immense performance improvement can be made by focusing the students on the problem and then aiding them in discovery of the factor relationships specific to that problem.

Remarks

Inquiry theory drives one to describe a problem and its solution in terms of the factors and variables that have an effect. These factor and variable interrelationships are the declarative basis for productions. Therefore, the discussion of these interrelationships amounts to the elaboration that lays the foundation for productions to be compiled and, consequently, skill learned or modified. In light of ACT-R, it follows that Inquiry theory is an effective and efficient method of knowledge acquisition and problem solving.

Future research planned for Sherlock II involves testing its effect on collaborative learning. (Katz & Lesgold, 1993) This research will implement Sherlock II as a background tutor, providing help upon request, to problem solving groups. As such, valuable insights into participation in a problem solving discussion may be acquired. This effort is potentially the proof of principle for the Inquiry approach outlined in this chapter.

In the meantime, one may wonder whether or not the ideas behind Smithtown and Sherlock can be generalized to a unit of trainees. Assuming that each trainee intends to learn and improve performance, the short answer to this question seems to be "yes." The reason Smithtown and Sherlock are so successful is that they employ a logical instruction process that matches the way humans process information to learn. Effectual facts are related to the causal facts at a level commensurate with the individual's skill. Although there are many levels of skill within the military group, each has the goal of understanding the knowledge at his skill level *and* within the context of the collective skill level of the group. Each trainee must understand how what he knows and does fits in with the group's actions and interactions. Obviously, if the assumption that individuals are training to learn is invalid, then, at the very least, the result will be less than full participation in the AAR process. The nonconformist trainees will not learn and the unit will not benefit from their perspective.

The nonconformist trainee will impact on the unit's learning synergy. Each member of the group benefits from multiple perspectives that enhance the elaboration of learning points. Because someone of comparable skill and knowledge can relate it to what the individual already knows, the learning point can be explained to each team member more efficiently. By making each responsible for the other's understanding of a learning point, this last point is a good argument for increasing participation in the AAR discussion. This idea was confirmed by Hollenbeck et al.'s (1995) group decision making research and explained by Anderson's theory of cognition (1993).

An additional argument for the generalizeability of Smithtown and Sherlock is the nature of the military unit's mission and organizational structure. In this structure, the unit leadership is responsible for leading the unit toward a single goal in the AAR: performance improvement. The hierarchical structure combined with the fact that a small unit's primary responsibility is to improve their own performance are the motivations to collectively learn. Army units do not train for any other reason; their readiness to go to war is dependent upon how well they perform in training. Thus, the group will work together to achieve that goal under the hierarchy of supervision. It follows then that the unit can collectively employ Inquiry theory, or any other method of performance improvement, as long as their leadership chooses to accept it. Research conducted by the Naval Air Warfare Training Systems Division (NAWCTSD) supports this position.

Using a structured AAR method called "guided team self-correction" in an operational setting, Smith-Jentsch et al. (1996) found that collective performance was significantly enhanced with respect to an unguided, unstructured method. In a laboratory setting, the guided team self-correction method improved leaning when compared to teams that were debriefed with a critique (i.e., one-way communication from evaluator/trainer to a team). (Tannenbaum et al., in press; Smith-Jentsch et al., 1996; and Smith-Jentsch, 1996a) Both of these findings support the hypothesis that the Inquiry approach can be generalized to unit learning (as indicated by performance improvement).

Guided team self-correction is an AAR technique specifically designed for shipboard combat control operator teams. The technique is task-based in that it

emphasizes *what* (behaviors) the team must focus assessment on in order to improve. (Smith-Jentsch, 1996a and b) The cause-effect performance factors are identified and stable with respect to the shipboard (immediate) environment. On the other hand, the Inquiry approach provides trainees a *how to* method for performance diagnosis when the causes are unknown and/or effects unclear. The difference between the Army and Navy performance situations is that Army units operate in environments that are more dynamic. The Navy team's environment, the ship's combat control center, is stable and therefore not a source of performance variation. Notwithstanding, the main point is that guided discovery techniques can improve both collective and individual performance.

Effectiveness of the Proposed Approach

Participation

As shown in Chapters II and III, participation is a key and elusive ingredient of an AAR. The proposed approach assigns the AAR leader the responsibility to prompt, monitor, and reward participation during the AAR. In actuality, this was one of the original duties of the AAR leader when the AAR was being developed as a training feedback concept. (Scott, 1983, Bosley et al., 1979, Shriver et al., 1975, and USAIS, 1974) These same sources point out that once the soldiers are participating, momentum is gained and any discussion inhibitions are lost. Observation of the 4 participatory, discussion focused AARs and subject matter experience confirm this observation.

The AAR leader must also provide feedback to individuals and the group on their participation in the discussion. (Argyris, 1994, and Smith & Kight, 1959) The study of 17 AARs in Chapter III confirmed that elements of participation increased with feedback. Hence, if the AAR leader can verbally laud a soldier for contributing to the discussion, he and the other unit members will be more likely to participate. This feedback responsibility augments Collins' Inquiry strategy of *questioning authority*. This is the strategy that requires the trainees to be self-reliant in learning. They do not rely upon the AAR leader or senior trainer for answers but must find them on their own. This frees the AAR leader to identify "bugs" and facilitate articulation and elaboration by suggesting the use of the terrain model, chalk board, or reference manuals.

The AAR leader can also physically involve participants in the AAR. He accomplishes this by having different soldiers draw concept sketches on a blackboard, move personnel or vehicle models on a terrain board, etc. This gets the soldiers out of their seats where it is too comfortable to sit passively. Participation by physical movement can be a first step toward influencing a person to submit his ideas verbally.

Whiteboards and terrain models can also help the participant articulate his point. Many combat arms soldiers cannot verbally communicate effectively. These aids can help soldiers organize their thoughts and explain relationships to one another; thus, they help the participants elaborate the learning points.

Hence, it is the AAR leader's responsibility to actively monitor and facilitate participation. He accomplishes this by explicitly setting participation as an objective of

the AAR and actively attending to that objective. He must be sensitive to the trainees' inhibition to submit observations and ideas for discussion. Additionally, he must beware of inaccurate or incomplete articulations and intervene to prompt correction or completion of statements. Inaccurate statements can easily be corrected by asking the trainee group, or a specific individual, to verify or correct the statement. The AAR leader must ensure that all the participants who were involved during the training exercise submit their experience. Those who have trouble explaining what they saw and why they acted are encouraged to use articulation tools such as the terrain board or whiteboard.

The AAR leader also must encourage dissenting views so that participants are forced to critique and defend their arguments. Once their arguments are on the table for critique, those participants have a vested interest in participating in the discussion. If a participant's argument is proven faulty by the group, the AAR leader must minimize the individual's embarrassment by rewarding him for offering the comments and encouraging his continued input. He can do this by pointing out the components of the argument that have merit despite the overall failure when the components are combined. This draws the groups attention to what is said and not who said it. If the AAR leader can influence the group to collectively critique the ideas in a rational manner without respect to who submitted the idea, then individual inhibitions will be perceived as less of an obstacle to participation. (Argyris, 1994)

The AAR leader has one irrefutable argument that he can use to motivate participation. As soldiers in the US Army, it is their duty to conduct and participate in

training. Since the AAR is a part of that training, then they are also duty bound to participate in the AAR. The soldiers may need to be reminded that participation means active contribution and not passive reception. This argument combined with a reminder that the AAR is for their benefit – to improve their performance and nobody else's – was a substantial influence toward open discussion in the AAR study. (Chapter III) The AAR leader must de-emphasize his own role and emphasize the trainees' role. This is fundamental to establishing an environment in which the trainees take ownership of the discussion and the ideas that are developed during the discussion.

Discussion Focus

Smithtown showed that the application of Inquiry theory to a group of students increases the effectiveness and efficiency of learning the problem solving methodology as well as the subject content. If done well, Inquiry teaching fosters multiple hypotheses and argumentation among the group. (Collins, 1987, 186) Hence, the implementation of the theory will increase participation and the number of points of view volunteered during the AAR. The theory's application will also increase the elaboration and articulation efforts of a participant as he submits and defends his views and hypotheses. This effort translates into individual improvement as each learns what and how cause and effect relationships affect performance. The unit improves as the shared mental model becomes more clearly defined during the discussion.

The focus of the discussion is critical to AAR effectiveness. To correct a problem, the problem itself must be studied. Beginning the AAR discussion with the BDA was highlighted as a time efficient method for participants to *identify* a problem topic. (Chapter II, 27, Chapter III, AAR Survey) If the process is followed, the AAR participants are guided to meet the doctrinal purpose and objectives of an AAR discussion. Specifically, this is what happened, why it happened, and a comparison of proposed solutions of how to do it better. Inquiry theory is a time efficient and thorough method of *focusing discussion on* a problem topic. As Word pointed out, the more time and effort spent on clarifying why something happened, the easier it becomes to realize how to correct the problem and, subsequently, generalize the solution to another situation. (Word, 1987, 34)

Using the BDA from a training exercise as a point of departure, a casualty at a specific point of the battle, for example, can be selected as the dependent variable. The participants then use Inquiry strategies to systematically identify the factors that caused the casualty and the variables that influence those factors.[39] Given a specific outcome of a training exercise, the questions that the participants need to address, in order, are:

1. What are the factors that caused this outcome?
2. What are the variables that affect these factors?
3. How do they interrelate to cause the outcome?

[39] In this case, I am defining a "factor" as a set of variables that can be logically grouped. An example of this could be the METT-T (mission, enemy, terrain, troops, and time) conditions of a battle. Each consists of a number of variables, i.e. terrain: weather, vegetation, relief, visibility, etc.

4. Which factor(s)/variable(s) can be adjusted to alter the outcome?

5. Can the desired outcome be achieved by controlling these factor(s)/variable(s)?

Answering these generic questions will determine why something happened and how to do it differently.

The important point at this juncture is to be thorough. All of the factors that affected the outcome must be identified. Repeatedly applying these questions to a situation and outcome will reveal the root cause(s) of the outcome and the necessary interventions to alter the outcome to the desired state. These interventions are the adjustments to factors that the participants hypothesize will affect the outcome. They are *forming hypotheses* and *varying cases systematically.* Obviously, the unit can only affect the factors and variables that they control.

The next step is to *test the hypothesis* under the training conditions in which the unit performed to prove that the desired outcome can be achieved. If the outcome is not affected or the desired outcome is not achieved, the unit has two courses of action. Either the unit can *trace the consequences to a contradiction* and correct the misconceived interrelationship, or it must begin the analysis to identify the factors, variables, and their interrelationships over again and re-hypothesize the factors and variables that will affect the outcome.

If the desired outcome is achieved, then systematic testing must be conducted to determine over what range of conditions the hypothesis holds for. This inquiry strategy is called *generating hypothetical cases* and causes the participants to generalize the factor

and variable relationships to differing situations. Essentially, each of the hypothetical cases becomes a new hypothesis that must be tested and proven true or untrue. The hypotheses, set of relationships that affect and achieve the desired outcome, are the answers to the question of how the unit can perform to achieve the specified performance measure/outcome – improve performance. The factors that are common to each hypothesis that is proven true are the conditions and actions that must be replicated and performed in future training to achieve the improvement.

The end result of the Inquiry approach is that the participants know: 1) what happened; 2) why it happened with respect to the battlefield conditions, other actions, and doctrinal principles; and 3) given different battlefield conditions, how to manipulate different resources under their control to achieve a desired effect. They will have articulated and elaborated the future training task, conditions, and performance standards needed to reinforce the behavior required to achieve the desired effect. This is the future training plan.

Via the Inquiry process, the participants will gain a greater understanding of the doctrinal factors, variables, and interrelationships that affect unit performance through discussion amongst themselves. Inquiry theory focuses the discussion on what is important and guides it to the end result of how to do what is important better. The use of Inquiry strategies allows one to construct, reinforce, and delete production links effectively and efficiently, in real time. The result is improved performance.

In other AAR systems, the focus *and* guidance of the discussion were the AAR leader's sole responsibility. Furthermore, in most of the AARs surveyed, the AAR leader presumed the content of the discussion. This is why AAR leaders tend to lecture and dominate the AAR discussion. Inquiry theory automatically guides and focuses the discussion, leaving the AAR leader to concentrate on reducing the inhibitions to discussion participation.

The AAR participants learn the Inquiry strategies and approach through repetition. It is intuitive that repeated exposure to a specific approach teaches the trainee that approach. Anderson's ACT-R theory of cognition verifies this idea – the process becomes proceduralized. (Anderson, 1993). For example, someone learning how to check the oil level in an engine block repeatedly pulls the dipstick, wipes it clean, reinserts it into the crankcase, withdraws the dipstick again, and then reads the level. After checking the oil levels in 10 cars, he cannot remember what the levels were, but he can remember the process that was used.

Medical diagnosis training also provides a common example of repetitive practice and elaboration to learn a complex process. Interns must spend a year diagnosing patient after patient under rigorous supervision to learn the process of accurate diagnosis. (Bruffee, 1993, 24 through 25) The routine use of Inquiry strategies to diagnose performance is a similar process. Units and individuals will learn that process by conducting a number of standardized AARs over an extended period of time.

Time

As stated before, the application of Inquiry theory is a time efficient method of solving problems. With respect to ACT-R, Inquiry theory identifies the concatenation of productions that define the problem skill. (Anderson, 1993, 33 through 34) The use of this methodology ensures that the discussion is focused upon what is relevant – the factors and variables that affect unit performance. Therefore, if the Inquiry approach is followed and the discussion topic is appropriate, the AAR time will not be used in the aimless exploration of irrelevant data.

Inquiry theory also supports the quick preparation of the AAR simply by utilizing the participant's knowledge of the exercise. The exercise information does not need to be prepared and presented in a specific format. If the AAR is conducted immediately after the training exercise, then the trainees can recall the information at relevant points during the inquiry process. An alternative is that the simulation training system's data collection system responds to real time requests to present the relevant performance information. This obviates the need to construct a pre-formatted presentation. The information that must be provided to begin the AAR is the data associated with the performance standards of the training tasks – the performance results. These are the collective task standards that are specified by the objectives of the training plan.

The system can work equally well for live simulations. Given that the trainees can act as the repository for exercise information, the AAR leader needs only the summary of performance outcomes relevant to the training objectives and doctrinal

performance standards and training in the Inquiry problem solving approach. The Inquiry strategies are a collection of topic focused, open-ended and leading questions. The Inquiry approach will efficiently guide the AAR participants through their own memory of the exercise and knowledge of doctrinal relationships.

The AAR leader's skill at employing the Inquiry strategies will determine how much effort his is able to dedicate to discussion participation. As found in the survey, the AAR leader who was unskilled in the questioning technique spent most of his time and effort in the formulation of questions. Consequently, he had little time to give participation feedback.

Learning Reinforcement

Once the interrelationships between a number of factors and variables are understood and the conditions to which they apply are known, the key to learning is repeated elaboration and practice. This is intuitive – it makes sense. With ACT-R, Anderson convincingly demonstrated that learning is the conversion of the declarative factor and variable interrelationships to production rules through the generalization of previous experience. Trainees must relate the new declarative facts and productions to what they already know. The key to a group learning complex collective tasks is that the group's common experience is iteratively generalized and practiced.

The task to be learned becomes complex when people must rely on each other to perceive environmental cues and then perform the appropriate portions of the overall task.

This complexity makes the task difficult to collectively accomplish as a team. The task becomes even more complex when team members: are dependent upon each other, are allowed to communicate only intermittently, receive too many environmental cues to process, and the consequences of action or inaction are both emotionally significant and life threatening. At the small unit level in this environment, living or dying depends upon the group of soldiers performing a specific sequence of actions. First, they must understand and work toward a common goal; usually the destruction of the enemy force. Second, they must individually and collectively interpret the battlefield cues so that they perceive the same meanings and significance; this is the hardest step of all. Third, given the perceived conditions (cues), they must individually and collectively select the same action or reaction in order to achieve the common goal. Fourth, they must execute that action in a uniform manner such that everyone understands what already has, needs, and remains to be done. The trainees must construct a shared mental model.

The reinforcement of acquired knowledge in the AAR is needed to both build and learn the structure of a shared mental model. In the proposed AAR approach, the reinforcement occurs as collective mental practice and hypothesis testing. After the factors and variables that affected performance during training are defined, the trainees generalize these interrelationships to different situations. To do this, the trainees must mentally vary the independent factors and variables under their control to achieve the desired effect in the given environment – this amounts to mental rehearsal. The ability to test the generalization with the testing component signifies the generalized conclusions.

In this exercise of hypothesis formulation and testing, each trainee can input considerations for both. This participation helps to ensure the hypothesis formulation and testing are necessarily thorough.

There are a number of tools available to facilitate hypothesis formulation and testing. Whiteboards (or large sketch pads) are common in CTC and homestation training AARs. (CTC AAR survey and subject matter experience) Word (1987) and Scott (1987) emphasized the use of a scaled terrain model. Personal subject matter experience confirms that the terrain model greatly enhances elaboration and articulation of the considerations needed for hypothesis formulation and testing. In Appendix E, Proposed Design, a 3D holographic projection system and a constructive simulation are suggested for terrain model creation and hypothesis testing respectively.[40] Thus, the hypothesis test results' significance is further reinforced by the holographic display which enhances the trainees' visualization ability. The trainees realize the required actions for performance improvement when presented different battlefield cues by physically seeing them.

A constructive simulation could facilitate mental practice. The replay of generalized hypotheses would allow the trainees to elaborate on the actions necessary to achieve a specific goal. This elaboration is important to relating the hypothesized actions to tasks and subtasks the trainees already know and understand. In terms of Anderson's ACT-R theory of cognition (1993), this elaboration is strengthening the connection

strength between the productions that were derived in the AAR and the productions that already existed from previous training and experience. The stronger the tie is to what is already known, the more efficient the recall is of what was just learned. (Anderson, 1993) The simulation could enhance the trainees' visualization as they iteratively solve sub-problems by analogy. Of course, combining this mental rehearsal with physical rehearsal will strengthen the connection so that recall is even more efficient. More is said on how a constructive simulation could be used in this manner in Appendix E, Proposed Design.

An important benefit of this approach, besides a common mental model of responses to the battlefield environment, is that the trainees understand what mission, enemy, terrain, troop, and time conditions are needed to train the unit so that a specific outcome is achieved. Plans for future training are developed and tested during generalization. The trainees realize what battlefield cues are absolutely necessary for the training of a specific task. This is important because training resources dictate what battlefield cues can be realistically replicated for training.

If the unit knows its resource needs then it can request those resources and plan training accordingly. Often, what occurs instead is that units know what tasks must be trained but do not consider what resources are needed. Unfortunately, they train the task with the available resources which is often a hit or miss undertaking. Quite simply, either the available resources combine to create the necessary cues to elicit the actions that need practice, or they do not. The proposed system will highlight the needed resources for the

[40] A good example of the holographic projection system envisioned is the Laser-based, 3D Volumetric

corrective training of specific weaknesses and the sustainment training of specific strengths. With this knowledge, units can either acquire the needed resources for training or train on tasks that the available resources will support, but they will not *unknowingly* waste time and effort trying to achieve a specific performance effect by training tasks that cannot be properly resourced.

Display System. (Soltan et al., 1995)

CHAPTER V

FINDINGS, LESSONS LEARNED AND SUGGESTED FUTURE RESEARCH

> "...the far object of a training system is to prepare the combat officer mentally so that he can cope with the unusual and the unexpected as if it were the altogether normal and give him poise in a situation where all else is in disequilibrium...the beginning lies in a system of schooling which puts the emphasis on teaching soldiers how to think rather than what to think even though such a revolutionary idea would put the army somewhat ahead of our civilian education."
>
> – S. L. A Marshall
> Men Against Fire, 1947

This research considered the AAR in light of Army doctrine, AAR research, performance feedback (behavioral psychology), and cognitive learning theory literature to determine the elements of an effective AAR. Given these elements, a methodology was then developed to assess effectiveness in an actual AAR. An analysis of 17 CTC AAR cases provided insight to some deficiencies with respect to the elements of effectiveness. This study and a review of current simulation training AAR support systems are used as the basis to suggest the AAR's current state and potential with respect to effectiveness. A derivation of Inquiry theory, an instructional strategy of meta-cognitive skills, was presented as an approach to overcome these deficiencies and achieve effectiveness in an AAR.

Findings

Learning does not require detailed and laborious erudition. Humans learn through the systematic acquisition of knowledge by analogy, this is the dynamic combination of declarative and procedural knowledge with respect to what is already known and a problem goal. To collectively learn, the group must develop a common understanding of the problem space and solution – a common mental model of what is wrong with performance and how to improve it. The requirements for this development are:

1. A knowledge-based domain;
2. Objective performance feedback (based upon what actually happened) that supports the doctrinal task based training system;
3. An AAR leader who guides and focuses discussion and provides participatory feedback to the group;
4. Articulation tools to aid in defining the problem space;
5. A logical problem solving methodology that requires problem definition, cause-effect factor analysis, and solution testing;
6. Elaboration tools to aid visualization and mental practice; and
7. Training tools to aid physical practice.

An effective AAR system must: promote, if not require, participation by all of the trainees; focus discussion on the learning points that affect performance; reinforce the learning points through hands-on application of problem solutions; and allow timely conduct of the AAR. These elements are interdependent. The key to achieving the first,

second, and fourth elements of effectiveness is the employment of a structured problem solving method combined with a discussion facilitator who provides participation feedback to the group. The discussion is where the learning that affects (improves) performance takes place. The Inquiry approach is the structured acquisition of new facts in a logical sequence so that the right associations can be made and productions formed. In effect, the approach guides the efficient and effective construction, reinforcement, and modification of productions. The application of Inquiry theory translates into efficient learning.

The third element of effectiveness, learning reinforcement, is not considered by the doctrinal AAR process nor simulation training AAR subsystems. Learning reinforcement allows the unit and individuals to proceduralize the learning point through verbal elaboration and physical application. In other words, trainees *learn* through mental and physical practice. AAR participants need tools that facilitate self-elaboration and allow timely practice of the learning points discussed. Hence, this component also has a time sensitive element. Trainees must practice what they learn as soon as possible before the declarative knowledge representation decays.

A systematic problem solving approach combined with elaboration increases learning and performance. It is achieved with Inquiry theory by questioning and explaining the learning points of the AAR. Elaboration can be pursued most efficiently as a group discussion since multiple perspectives are offered and articulated. The

multiple perspectives help each individual realize the learning point by relating it to what he already knows.

Self-elaboration is a method to problem solve by analogy. ACT-R provides a clear and plausible theoretical basis for the premise that elaboration is needed to learn, as demonstrated by both Smithtown and Sherlock. These systems employ versions of Inquiry theory to elicit elaboration of learning points from the student, keep the student focused on the learning point until he understands it, and then require him to apply or demonstrate the learning point. The mechanism that allows the student to understand the point is iterative elaboration of experience. In the end, self-elaboration becomes synonymous with mental practice.

An AAR, or performance feedback, system needs components and processes that prompt and focus discussion. These components serve as a medium for discussion. They help the trainees learn by articulating and elaborating concepts, rules, and theories to a point of common understanding. The AAR system components must also provide for learning reinforcement of the discussion points. This provides the unit the opportunity to physically implement or practice the learning points they have elaborated and articulated; thus, imbedding the points in their experience and specifying the conditions for future training.

The final requirement is that the approach must not prolong AAR preparation but allow timely learning reinforcement. For platoon and company level training exercises, the AAR must commence within an hour of the termination of training. The duration of

the AAR is usually limited by time because of training system co-use with other units. Therefore, the AAR's duration must be dedicated to efficiently learning rule and theory relationships that affect performance and not by lectures of what and what not to do. Hence, the AAR system must get participants into the mode of discussion as quickly as possible.

In summary, the goal of the proposed AAR approach has both short and long term orientations. For the short term, the objective is to increase the trainees' level of expertise and improve performance with respect to doctrinal standards. The long term objective is to create a collaborative learning environment in which the unit learns the problem solving skills necessary to efficiently diagnose and critique performance. This approach supports the overall goal of the AAR: to improve individual and unit performance.

Research Limitations

The methodology to measure effectiveness of an AAR does and will not indicate *how much* the unit learned. It only indicates whether or not the conditions for more efficient learning are created. Although the survey is only an indicator of the AAR system at the CTCs, it does strongly confirm my subject matter experience; AARs are generally non-participatory and do not focus on how a solution can be implemented so that the unit learns. Even though the CTC AAR system is the example all follow, units vary in the implementation methods of that example. Hence, a larger sample (n) is

needed to make a conclusive assessment about how effective AARs are across the Army. There will most likely be an extreme variation between unit AARs for the simple reason that doctrinal AAR guidance is not a standard subject taught in Army schools.[41]

The survey *is* an indication of infantry and armor platoon and company AARs. Other unit types, field artillery, air defense artillery, military police, etc…, were not surveyed. Nor were Air Force, Navy, and civilian organizations that employ training feedback studied. The other branches of the Army and military services are more technically oriented than infantry or armor organizations. Indeed, the infantry organization is the only one whose most important system is the soldier. The armor units include the tank crew (the people) as a component of the tank system. The point is that the technically oriented organizations require more technical and individualized feedback. (SHERIKON, 1996b) For example, the pilot in the F-16 is most concerned with his ability to fly the airplane, as he should be. Notwithstanding this technical nature, the Inquiry approach should accommodate any (individual or collective) performance oriented, task based, training system. Hence, fire departments, police departments, and emergency medical teams could all benefit from this approach and subsequent research. Furthermore, higher level military organizations such as brigade and division staffs could also employ the Inquiry approach. That is, if they are willing to submit their actions to scrutiny in terms of tasks with measurable performance standards.

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[41] Army schools are officer/NCO basic and advanced courses, staff schools, and command courses.

Lessons Learned

Problems

Defining Participation

Participation is not described adequately in research literature. Conclusive studies have not been conducted to show when and how participation affects learning. More to the point, the factors that motivate a person and group of people to proactively participate in a potentially embarrassing discussion (where, at least, self-esteem is at stake) have not been isolated and demonstrated convincingly. Current and future research in collaborative learning should provide the necessary empirical evidence.

It is, however, intuitive that participation positively affects learning. Although not directly measured in the AAR study, participation seemed highest when practical solutions were being discussed. In other words, trainees were motivated to solve problems. Conversely, when solutions were obvious, irrelevant, or not discussed at all, trainees were less motivated to participate. Once shown, this evidence will provide the basis for the R & D of simulation tools to directly increase participation in a group learning setting.

Survey Methodology

Variability in data collection was not adequately controlled. Although data collection was practiced on two AARs, an analysis to measure the reliability of collection was not done. Undoubtedly, there is some variability in data collection between and,

perhaps, within an AAR. There are two ways to easily reduce some of this variability. One is to watch the tapes twice. This would allow data to be recorded that had been missed the first time. The second is to utilize multiple recorders for the AAR leader and groups of trainees. This option would ensure that a data collector is observing only a small number of participants at one time. In the AARs observed for this study, an observer could easily record the data for four participants.

Multicollinearity was a problem in the regression analysis. This resulted in some of the findings from the trend analysis not being statistically verified. An initial solution to this problem is to transform the variables with a logistic response function. (Neter & Wasserman, 1974) This would allow a smoother approximation of correlated variables in each regression model.

A second possible solution is to redefine the variables so that they are not correlated. For example, the unit attitude and unit leader action variables would require a detailed analysis of the unit leader – trainees relationship to determine factors that differentiate their behavior with respect to one another. Consequently, the resultant relationship would have to be validated with a number of different groups.

Recommendations for Future Research

There are two main areas for future research. The first area concerns the elements of AAR effectiveness and completion of AAR study. The second concerns the requirements to implement the Inquiry approach in an AAR system.

The first priority for future research is to prove that discussion participation, discussion focus, learning reinforcement, and timeliness each affect learning positively. This step would validate the literature research that developed the elements of effectiveness. This effort will impact any future study of AAR effectiveness by clearly establishing a relationship between specific factors and successful learning in the AAR environment.

A follow on research effort would be to increase the sample size of AARs in the study conducted in Chapter III. By redefining the variables IAW the findings in the above proof of principle, a clear articulation of what is actually occurring in an AAR can be achieved. A sample size of at least 50 is probably needed to draw conclusions for the CTC AARs. This would be relatively simple to conduct since a portion of AARs are videotaped each rotation.

However, an idea of how AARs are conducted during home-station training is also needed. This will indicate how the doctrine and example set by the CTCs are implemented. Sampling these AARs presents a couple of problems: 1) few of these AARs are videotaped and therefore, 2) data collectors would have to be present to observe or record the AAR. The presence of the data collectors alone may affect the way the AAR is normally conducted or how the trainees normally act. An option may be to conduct a written survey of unit leaders to determine what elements of an effective AAR they implemented. To reduce the survey participant's subjective interpretation of the questions, a videotaped example of each question may need to be provided.

The second area of future research is required to support the implementation of the Inquiry approach. First of all, the examples demonstrating learning efficiency of the Inquiry approach need further analysis. Both Smithtown and Sherlock exhibited some of the Inquiry theory strategies, but not all of them. Littman et al. (1990) identified which strategies were most often used to diagnose student bugs. They did not compare the diagnosing effectiveness of each. Therefore, the questions that must be answered are: 1) Which strategies are most important?, 2) Are all 10 strategies needed?, and 3) Are the goals, subgoals, and control strategies still valid if only some of the questioning strategies are used?

The next step to the implementation is to prove that the Inquiry approach can be generalized to affect collective performance.[42] This would entail an experiment with three groups of units. Each experimental group should consist of at least 8 "subject" units to allow for a sufficiently large sample. A total of 24 units would be required. An infantry or armor brigade tasked to support this experiment could provide 27 homogeneous platoons as well as plan, prepare, execute, and evaluate the training exercises.

Table 5.1, AAR Technique Experiment outlines the training and AAR treatment methodology. The experimental treatments should include: 1) a baseline assessment (pre-test) to establish the unit's proficiency level; 2) a training exercise with common tasks, conditions, and standards followed by a group specific AAR treatment; and 3) a

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[42] "Collective" performance is military unit performance.

post-test assessment exercise. Most likely, the pre-test will have to consist of a performance oriented test that is also externally evaluated.[43]

Table 5.1, AAR Technique Experiment

	Group A	Group B	Group C
Baseline assessment (Pre-test)	×	×	×
Standard training exercise	×	×	×
Inquiry approach AAR	×		
CTC AAR		×	
External evaluation training exercise (Post test)	×	×	×

From this experiment, one can determine the learning gain that results from the training and the AAR technique. The hypotheses to be tested are:

H_1: Employing the CTC AAR technique improved performance more than training with no AAR.

H_2: Employing the Inquiry approach AAR improved performance more than the CTC AAR technique.

[43] "External" means not organic to the unit being tested. These evaluators should come from another unit and not have an undefined interest in the test results.

As long as the training conditions for each unit are the same, the performance improvement can be attributed to the AAR.

The last implementation step would then be to determine the best method of presenting the Inquiry approach during the AAR. In Appendix E, Proposed Design, I suggest an Inquiry Tutor component to support simulation training system AARs. Simply, this is an expert system that outputs Inquiry strategies in response to data input during the AAR. This requires an Inquiry Tutor operator, separate from the AAR leader, unless an input method that does not detract from the AAR leader's participation monitoring responsibility can be found. Once this form is identified, separate training systems can be designed to train the Inquiry approach with respect to the AAR. These training systems could be individual intelligent tutoring systems or even virtual world training systems for collective AAR leader training.

Epilogue

Training

To implement the Inquiry approach for performance feedback, there is a requirement to train unit leaders. This training should be provided at home-station as well as basic and advanced schools. The goal should be to train unit leaders to utilize the approach. This would allow leaders to employ the approach in live training AARs that are unsupported with simulation-based data collection subsystems. Additionally, the

Inquiry approach teaches individuals and organizations the meta-cognitive skills necessary to learn efficiently. This instruction will transfer to many academic disciplines as Collins had found. Therefore, soldiers will continue to realize the benefits well after their military careers.

If the study of 17 AAR tapes is indicative of the majority of AARs conducted in the Army, then some training must be focused on increasing participation. Argyris' theory does include some optimism for trainee participation. A surprising point that he repeatedly makes and supports with evidence is that individuals are not aware that they are implementing Model I strategies to pursue the governing goals. However, individuals are aware of others doing so. (Argyris, 1994, Chapters 1 through 8) According the Argyris, this consistency is a factor in the modification of Model I behaviors into Model II behaviors. A solution Argyris proposes is to assign a trained person the responsibility to intervene in group meetings. Specifically, he should make people aware of Model I tendencies by exposing the defensive reasoning they use to rationalize those tendencies. This person becomes a facilitator – a "summarizer of opinions," "clarifier of feelings," and "instigator" of opposing arguments. (Argyris, 1994, 194 and 221) Not only is this solution ready made for the AAR leader but is in keeping with doctrinal guidance to facilitate the discussion.

The main problem with the above solution is that it will take nearly all of the AAR leader's concentration to monitor trainee behaviors and intervene with the appropriate action. But if he does not intervene, the problem of discussion participation

and its underlying causes will not be redressed. I believe that this problem can be adequately addressed with the approach advocated in Chapter IV and the support of current technology in military simulations and AAR subsystems.

A secondary problem with Argyris' solution is that it requires a person trained in Model I behavior diagnosis. There is little doubt that the facilitator needs this training. Without it, his feedback to the group would be ineffective. The feedback he does provide must have the theoretical basis of Argyris' Model I and II theory. The training requirement may be satisfied by simply reading and conducting group discussions of On Organizational Learning (1994) with respect to specific learning objectives. This training solution is ideal as a block of instruction for officers and NCOs in the company grade branch courses (officer and NCO basic and advanced courses).

Simulations

R & D efforts should focus on tools that will aid articulation and elaboration, as well as accommodate immediate retraining. AAR subsystem functionality stops with the display of performance data. Their focus is on efficient and complete data collection and facilitation of data manipulation for later use and presentation. However, there is little effort to create and design tools that support deficiency correction or reinforce learning. A concept of such a tool is presented in Appendix E, Proposed Design. It entails connecting a constructive simulation system to a 3D display. The idea is to create a

simulation-based component on which the trainees can test solutions in real time. This could aid trainee visualization and elaboration.

Task Analysis

The Inquiry approach is a knowledge acquisition technique. Essentially, the approach renders the elements needed to represent the subject domain as a GOMS model.[44] Users of the Inquiry approach break performance tasks into fundamental cause-effect relationships. These relationships can then be used to identify the knowledge units, skills, and abilities that describe the performance of the task. In this sense, the Inquiry approach is also an alternative knowledge elicitation method that may be used toward a detailed cognitive task model of military task performance.

The process to elicit and identify a task's basic elements (cognitive cues) is very expensive in the time and effort of both knowledge engineers and subject matter experts. For (Army) combat, collective tasks, the creation of realistic conditions is also expensive. Furthermore, the literature reveals that detailed cognitive task models have not been built for most military tasks. Given a continuance of the past and current governmental R&D paradigms, money will not be invested to build cognitive task models on which to base simulation training systems. Hence, the creation of detailed cognitive task models can be approached from the other end – iteratively building representations of performance from

[44] For task-based knowledge domains, the GOMS model is the knowledge representation method used when conducting a cognitive task analysis. (Williams & Kotnour, 1993)

whatever the simulation system can approximate. This can be likened to building a haystack by moving two to three straws at a time.

Simulation training systems provide a medium on which to observe and record the knowledge acquisition process that the Inquiry approach affords. The most attractive characteristic of this potential task analysis method is that the training conditions can be precisely recreated from the simulation system's data logger and the knowledge, skill, and ability elements identified as critical can be tested. Hence, the important battlefield cues and actions can be differentiated from those that are irrelevant. The AAR is important because the differences between "real life" and the simulation system will be highlighted. The analysis should be of the task performance in replicated combat conditions or "acceptable" approximations of those conditions. The universally accepted assumption is that to be valid in combat, the task performance must be verified by doctrine and reality. Therefore, any input toward a cognitive task model can not be generalized beyond the conditions of realistic simulation.

Arguably, the most realistic combat environments are simulated at the Live Fire departments of the CTCs. As such, these environments provide verification testing for any simulation-based training program (of a limited number of tasks below battalion level). The requirement for behavioral data, gathered from a simulation training system, to be verified in live training conditions cannot be emphasized strongly enough; it is criminal neglect to do otherwise. Until simulation training systems are built with respect to validated and verified (detailed) cognitive task models, a dire risk exists in which tasks

are trained in response to inappropriate or incomplete conditions. The performance will not transfer to combat. Consequently, a high initial casualty rate will accompany a steep re-learning curve as individuals and units strive to adapt their behavior to survive.

APPENDIX A

THEORETICAL FOUNDATIONS

"Humans learn continuously from all tasks they perform, at whatever scale the task occurs."
-- Allen Newell
Unified Theories of Cognition, 1992

"Cognitive skills are realized by production rules."
- John R. Anderson
Rules of the Mind, 1993

Problem Spaces

Beginning in the late 1950s, Herbert Simon and Allen Newell conducted the research and analysis that has evolved into the most popular framework of human problem solving and, consequently, the basis for a number of theories and models of cognition. (Simon, 1996) This framework and the seminal theory of meta-cognition are presented in Human Problem Solving (1972). They present a theory of human problem solving in Chapter 14. In the elaboration of this theory, Simon and Newell describe the features that are common to problem spaces. These characteristics describe the constraints and limitations followed by Langley et al. (1987) in their models of scientific rediscovery. The common characteristics of the problem space are listed in Table A-1, Invariant Features of Problem Spaces.

Table A-1, Invariant Features of Problem Spaces

1. Problem spaces can be represented as a closed space of knowledge – a set of knowledge states generated by a finite set of objects, properties, and environmental forces and their interrelationships.
2. The knowledge state is typically moderate in size. It ranges from a few dozen symbols to a few hundred.
3. The set of operators that can be applied to the problem space is small and finite (finitely generated).
4. The problem solver maintains one or two alternative nodes to which he may return during solution.
5. The problem solver spends seconds in each selected knowledge state before generating the next state.
6. The problem solver spends 10s of minutes in a given problem space.
7. Problem solving takes place by search in the problem space – incrementally moving from one knowledge state to another until the desired knowledge stated is reached.
8. The search retraces (backs-up) its solution path as needed.

(Simon & Newell, 1972, 810 through 812)

Learning and ACT-R Theory

In Intelligent Simulation Training Systems Design, Kent E. Williams (1996) reviews current cognitive theories of knowledge representation, knowledge acquisition, and problem solving. Theories of cognition attempt to explain how humans *process* and *recall* information to acquire skill. Problem solving, referred to as meta-cognitive skill, is how humans *use* the information processed or recalled. (Williams, 1996a) These

cognitive theories describe the underlying mechanism of the meta-cognitive processes such as Inquiry theory.

The most successful model at describing knowledge acquisition, performance, and transfer is Anderson's ACT-R theory of cognition. (Williams, 1996a) In Rules of the Mind (1993), Anderson convincingly posits that the success of modeling human learning and performance with ACT-R at least validates its production system structure. With this conclusion, ACT-R is offered as proof *that human cognitive skills are realized by production rules*. (Anderson, 1993)

Production rules (or productions) are *condition–action* pairs or if–then rules. (Anderson, 1993, 4 and 5) The *condition* side specifies the circumstances under which the action side will apply. The *action* side specifies what to do if the circumstances are satisfied. These productions form the basic units of skill. In other words, productions are what a student learns. Furthermore, the analysis to identify the production rules in a knowledge domain and then the teaching of those rules leads to efficient learning. (Anderson, 1993, Williams, 1996a, and Williams, 1995) The identification of critical knowledge units is the purpose of knowledge engineering.

Production rules have four characteristic features with respect to optimizing their utility in a system of productions. These properties are modularity, abstraction, goal structure, and asymmetry. These features are described below.

1. Modularity – productions are independent of each other and can be added or deleted as such. This allows productions to combine in different ways and produce

variations of behavior. Consequently, solving a problem is dependent upon the interactions among productions. Additionally, the weakest production determines overall performance. Thus, sets of productions can model erroneous behavior by the addition or deletion of productions. (Anderson, 1993, 31 through 32)

The modularity feature also justifies the position that cognitive skills are realized by productions. Productions are the basic units of a skill (procedural knowledge). Anderson proved this by conducting a detailed task analysis of programming in LISP. A task analysis specifies the structure of problems in a specific knowledge domain. By using productions to describe each problem, the analysis identifies the units in which skill is acquired. Anderson proved that LISP programming skill is acquired in production-sized units by accurately predicting how long students would take to learn to program a string of code. Programming skill increased by acquiring new productions and strengthening existing productions. (Anderson, 1993, 32 through 34)

2. Abstraction – productions can be generalized to different situations because they do not require a specific condition to fire. In other words, the "rules apply in any stimulus condition that satisfies the pattern specification of the condition." In ACT-R, the pattern specification of the condition is a concatenation of knowledge chunks. The configuration of these chunks is what matches the condition side of the production and causes the action side to fire. The content of the chunks is not a factor in the pattern matching. (Anderson, 1993, 35 through 37) Hence, different productions can share the

same stimulus conditions, and productions are strung together to achieve complex cognition.

3. Goal structured – production rule conditions specify definitive goal conditions. Depending on the internal goal specified in each of the conditions, different productions can fire given the same external situations. This allows the subject to respond differently to the same situation. (Anderson, 1993, 35 through 37)

Combining the features of goal structure and abstraction allows Anderson to accurately predict skill transfer. Anderson showed this transfer by measuring variable-coding errors in LISP. (Anderson, 1993, 36) In the first lesson, students learned the productions required to code variable names. Over the next three lessons, students were required to generalize the productions to new conditions, but with the same goal. Even though the stimulus conditions were different in all four lessons, students steadily improved performance. By lesson four, they averaged zero variable-coding errors. However, in lesson five the goal was changed and the number of errors increased. Performance deteriorated because new productions had to be learned. By counting the number of productions that are common to two tasks and the productions associated with the goal changes, Anderson is able to accurately predict how long it will take a student to generalize a skill. (Anderson, 1993, 36 through 37)

4. Asymmetry – The production's action is determined from the conditions, but the conditions cannot be determined from the action. Simply, the rule cannot reverse itself. The production system's efficiency is derived from the production rule's

asymmetrical structure because it reduces rule conflict. Anderson demonstrated this by comparing learning to write LISP code and learning to evaluate it. Each group that had prior training in coding or evaluation performed the best on those tasks. Those that had prior training in coding and the control group (no training) performed equally well on the evaluation tasks. While those that had been trained in evaluation did better than the control group in coding tasks. (Anderson, 1993, 37 through 38) The knowledge of coding was a subset of evaluation and this made the trained evaluators better at coding. Alternatively, the coding knowledge could not be reversed into the parent set of evaluation knowledge.

As a production system, ACT-R subscribes to the Simon's Two Concept Theory of Memory specified in the Human Information Processing Model of Cognition. (Williams, 1996a, Anderson, 1993, and Simon & Newell, 1972) This theory specifies that memory consists of two long-term memory stores, *declarative storage* and *procedural memory.* The declarative storage is a knowledge base of facts while the procedural memory stores productions – knowledge about how to do something. Conscious thought is represented as short-term memory or *working memory.* It receives input and has a capacity of five to nine working memory elements or *chunks* of information. A chunk is the basic unit for the organization of declarative knowledge. (Anderson, 1993, 25 through 29)

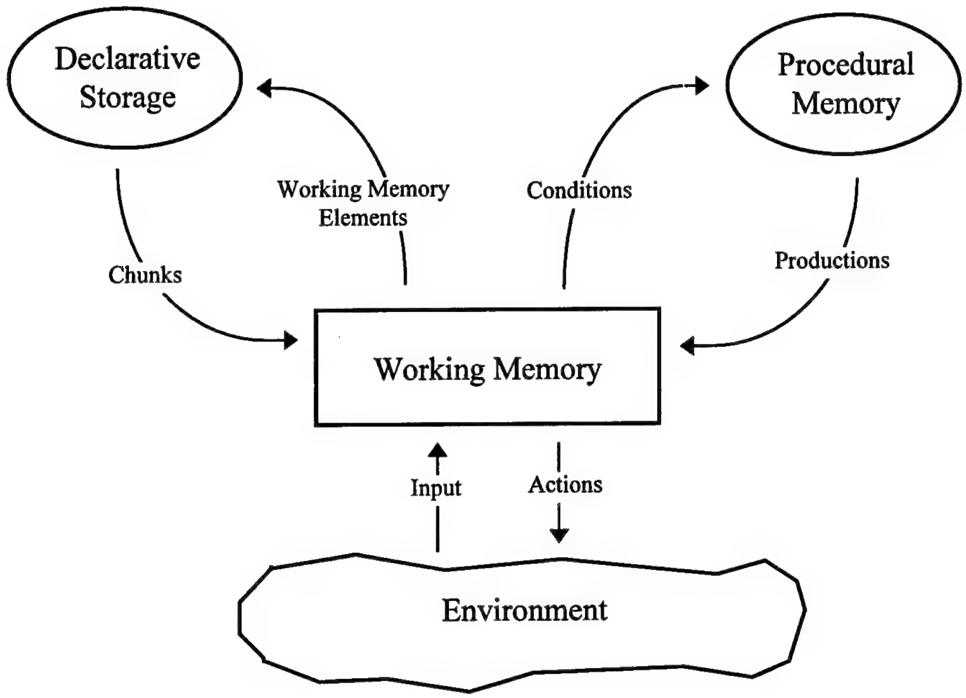

Figure A-1, Human Information Processing Model
(Williams, 1996a, and Williams, 1995)

There are a six properties that distinguish declarative from procedural knowledge. The first is reportability. This refers to the capability to explicitly declare or verbalize the knowledge. Declarative knowledge is reportable or potentially reportable, but procedural knowledge is not. (Anderson, 1993, 21) For example, knowing that Djakarta is in Indonesia is declarative, while the reading of a map to find Indonesia is procedural. Humans have a difficult time describing how they read.

The second property is associative priming. This is the learned association of two objects such that given one, the other is expected. For example, when one hears the word "computer," there is priming for the word "programming." Declarative memory has an associative priming process, procedural memory does not. (Anderson, 1993, 21)

Retrieval asymmetry is the third property. As stated before, this means that given the condition side of a production, the action side can be retrieved, but not vice versa. In other words, given the action side, the conditions can not be retrieved. This property applies only to procedural knowledge. (Anderson, 1993, 21)

Acquisition is the fourth distinguishing property. Declarative knowledge is acquired directly from the environment. Procedural knowledge, on the other hand, is compiled from declarative knowledge through practice. Procedural knowledge cannot be acquired directly from the environment. (Anderson, 1993, 22)

The fifth property is retention. For each type of knowledge, the retention functions are independent of each other. This property explains why people can improve the recall of procedural knowledge and at the same time regress in the recall of declarative knowledge. For example, the layout of the typewriter keyboard is declaratively memorized when first learning to type. Procedurally, the keyboard layout is known as part of the typing skill. Thus, the knowledge of the keyboard layout is represented *both* declaratively and procedurally. Furthermore, as the typing skill increases in efficiency, most people lose the ability to recall the declarative representation of the keyboard layout. (Anderson, 1993, 18 and 22)

The final property distinguishing declarative and procedural knowledge is dissociation. Cognitive research has shown that declarative and procedural learning are uncorrelated. (Anderson, 1993, 22) However, Anderson has proven that procedural learning is still dependent upon *active* declarative representations. In other words, subjects must be able to perceive declaratively in order to learn procedurally. After the productions are formed, the declarative representation does not have to be retained. (Anderson, 1993, 22 through 24) Hence, procedural knowledge and declarative knowledge are dissociated with respect to retention in memory.

Using a computer simulation of ACT-R and rational analysis, Anderson empirically proved that declarative and procedural knowledge units are converted into action as a function of their strengths, base-level activations, probabilities, and costs. (Anderson, 1993, 69) More specifically, he was able to determine that the selection of a production rule is determined by the interactions of nine factors and that this interaction can be accurately modeled using Bayseian statistical inference. (Anderson, 1993, 69) These production rule factors are listed below. The selection of a production rule (from procedural storage) is dependent upon:

- The goal that is currently active; this will spread activation to other goals and prime rules.
- The past history of use of various declarative chunks – the past probability that the chunk might be active.

- The elements in the current context - the patterns of chunks in working memory that activate and prime rules.
- The complexity of the rule. This is the number of chunks that must be matched.
- The past frequency of use of the production rule.
- The past history of success of the production rule; with respect to the goal.
- The amount of effort put into solving the problem so far – the cost (in time) of executing a production and its consequent productions.
- The similarity between the goal state and the state that results from applying the production rule. In a hierarchy of goals, this is the distance between the current goal and the desired goal end-state.
- What other options for behavior are available given that the goal state fails. (Anderson, 1993, 63)

These factors combine to decide the base-level activation of a rule and its strength of association. The resultant activation is the learning of that rule. As a consequence of activation, this rule activates other productions that also strengthen associations. (Anderson, 1993, 69 through 78)

The association strength connecting productions or chunks determines the pattern that is recognized by the condition side of the declarative and procedural memory. (Anderson, 1993, 76) This reasoning leads to an important effect that concerns learning –

the *fan effect.* The fan effect states that the memory access spread from a cue to a knowledge unit (declarative or procedural) decreases as the number of memories (links) associated with that cue increases. (Anderson, 1993, 77) Hence, the exercise that associates the cue with the declarative chunks in the most ways will increase the speed at which the desired procedural or declarative knowledge units are recalled. The key is to elicit the correct productions or declarative information and reinforce the association strength. The increase in associative strength then causes a corresponding increase in activation level. This is why skill practice and elaboration of context specific experience improve performance of that skill.

More specifically, ACT-R is a computational model of productions with the premise that learning is based upon what is already known – prior experience. This experience is stored in procedural memory and consists of the production rules with similar goals and/or conditions. (Anderson, 1993) With more elaboration and practice, these productions become situation specific, allowing the experience to be situation-based. The subject learns by iteratively applying that experience to a given problem.

ACT-R's implications for skill acquisition are summarized below. These derive directly from the argument *that human cognitive skills are realized by production rules.*

1. The knowledge underlying a skill begins in an initial declarative form (an elaborated example), which must be interpreted (problem solving by analogy) to produce performance.

2. As a function of its interpretive execution, this skill becomes compiled into production-rule form.
3. With practice, individual production rules acquire strength and become more attuned to the circumstances in which they apply; they become situation based.
4. Learning complex skills can be decomposed into the learning functions associated with individual production rules.

(Anderson et al., 1993, 143)

Given that production units are the basic units of skill, performing a detailed task analysis with respect to productions can improve performance. More efficient learning is achieved by using this analysis (of the production units) to specifically incorporate the identified knowledge chunks into the curriculum. (Anderson, 1993, and Williams, 1996a) Thus, the question arises of why task analyses, in production level detail, have not been employed in training systems? The short answer to this question is that the task analysis process is an extremely expensive venture in both time and resources. (Williams, 1996a, Williams, 1995, and Chapman & Allen, 1994) Despite the expense, computer tools that aid and facilitate the process of expert knowledge elicitation and representation have been and are being developed. (Chapman & Allen, 1994, and Williams, 1996b) In the meantime, less expensive methods must be used to learn more efficiently. One such method is Inquiry theory.

APPENDIX B

REGRESSION ANALYSIS

"We reason with scant evidence, vague concepts, heuristic syllogisms,
tentative facts, rules of thumb, principles shot through with exceptions,
and an inarticulable pantheon of inexact intuitions, hunches, suspicions,
beliefs, estimates, guesses and the like."
-- Kosko, 1992

Univariate multiple regression by backwards elimination was used to statistically confirm any trends found in the data. This analysis was conducted with MINITAB for Windows software. All regression models were tested to a statistical significance level (α) of 0.05. Multiple regression analysis was conducted for each of the quantitative measures for which data was recorded. This analysis indicated which factor(s) seemed to have a large or small effect on a selected dependent variable. Stepwise (forward) regression was used to verify the significant terms. Finally, Eigen analysis was used to test for multicollinearity.

The regression model outputs are labeled as output tables and include: the regression model; a list of independent variables and their corresponding coefficients (β),

standard errors, test statistics for testing $\beta_i = 0$, and observed significance p-values; the model adequacy measurements R^2 and R^2-adjusted; an analysis of variance table; and the eigenvalues for the X'X matrix. The variance inflation factor (VIF) is computed for the small eigenvalues.[45] A VIF $\geq$ 100 was considered a large value and resulted in the regressor variable(s) being removed from the model. Each output table (B-2 through B-10) corresponds to the summaries in Tables 3.11, Discussion Participation Factors, and 3.12, Discussion Focus Factors.

A list of dependent and independent variables and their definitions is given in Table B-1, Factor Definitions (next page). The raw data for these variables are in Table 3.5, Discussion Participation Data, Table 3.6, Discussion Focus Data, Table 3.7, AAR Leader Actions Data, and Table 3.8, Unit and Other Actions Data.

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[45] The VIF for the smallest eigenvalue is the ratio of the largest eigenvalue to the smallest eigenvalue. The VIF for the next smallest value is simply the ratio of the largest eigenvalue to the next smallest eigenvalue.

Table B-1, Factor Definitions

Factor	Definition	Type
PAR1	Unit : AAR leader utterance ratio	Dependent
PAR2	% of unit members participating in the discussion	Dependent
PAR3	Ratio of Unit comments : AAR leader questions	Dependent
PAR4	Discussion amongst the unit during the AAR	Dependent
PAR5	# Questions asked by the unit during the discussion	Dependent
TIME1	% of total AAR time used for discussion	Dependent
DuP	# *solutions planned* specified by the unit	Dependent
DuD	# *solutions developed* specified by the unit	Dependent
DtP	Total # *solutions planned* specified (by unit & AAR leader)	Dependent
DtD	Total # *solutions developed* specified (by unit & AAR leader)	Dependent
A	AAR leader used focused, open questions	Independent
B	AAR leader used focused, leading questions	Independent
C	AAR leader provided participation feedback during the discussion	Independent
D	AAR exceeded specified time limit	Independent
E	AAR leader established a participatory climate in the introduction	Independent
F	AAR leader used specific BDA during the discussion	Independent
G	AAR leader used sketches and maps during the discussion	Independent
H	# questions asked by the AAR leader	Independent
I	# questions asked by unit	Independent
J	Unit had a good attitude	Independent
K	Unit had a poor attitude	Independent
L	Unit leader aided/facilitated discussion	Independent
M	Unit leader hindered discussion	Independent
N	Unit specified *solutions planned*	Independent
O	Unit specified *solutions developed*	Independent

Output B-2, Unit : AAR Leader Utterance Ratio (PAR1)

PAR1 = 0.0892 + 0.969E - 0.541H + 0.820AB - 0.447O + 0.517CG - 0.269BE

Predictor	Coef	Stdev	t-ratio	p
Constant	0.08919	0.08328	1.07	0.309
E	0.9686	0.1269	7.64	0.000
H	-0.54058	0.07860	-6.88	0.000
AB	0.8196	0.1325	6.19	0.000
O	-0.4465	0.1182	-3.78	0.004
CG	0.5166	0.1869	2.76	0.020
BE	-0.2692	0.1102	-2.44	0.035

s = 0.1506 R-sq = 94.0% R-sq(adj) = 90.3%

Analysis of Variance

SOURCE	DF	SS	MS	F	p
Regression	6	3.52533	0.58755	25.90	0.000
Error	10	0.22687	0.02269		
Total	16	3.75220			

SOURCE	DF	SEQ SS
E	1	0.47641
H	1	1.47845
AB	1	0.88105
O	1	0.42516
CG	1	0.12900
BE	1	0.13525

Unusual Observations

Obs.	E	PAR1	Fit	Stdev.Fit	Residual	St.Resid
14	1.00	2.0100	2.0100	0.1506	0.0000	* X

X denotes an obs. whose X value gives it large influence.

Eigenvalues and variance inflation factors for PAR1:

2.25269	1.20224	0.48730	0.47225	0.20091	0.11025	0.02740
					VIF = 20	VIF = 36

Output B-3, % Unit Participation (PAR2)

PAR2 = 83.2 - 12.8 D + 18.9 G + 16.8 AB - 18.7 BG

Predictor	Coef	Stdev	t-ratio	p
Constant	83.205	4.247	19.59	0.000
D	-12.769	5.353	-2.39	0.034
G	18.897	6.515	2.90	0.013
AB	16.795	7.709	2.18	0.050
BG	-18.72	10.35	-1.81	0.096

s = 9.098   R-sq = 64.5%   R-sq(adj) = 52.7%

Analysis of Variance

SOURCE	DF	SS	MS	F	p
Regression	4	1804.82	451.21	5.45	0.010
Error	12	993.18	82.76		
Total	16	2798.00			

SOURCE	DF	SEQ SS
D	1	491.79
G	1	903.41
AB	1	139.05
BG	1	270.58

Unusual Observations

Obs.	D	PAR2	Fit	Stdev.Fit	Residual	St.Resid
10	0.00	100.00	83.21	4.25	16.79	2.09R

R denotes an obs. with a large st. resid.

Eigenvalues and VIF for PAR2

1.87160 0.75107 0.26257 0.17057 0.03394

VIF = 55

Output B-4, Unit Comment : AAR Leader Question Ratio (PAR3)

PAR3 = 0.848 + 2.00CF + 0.827A - 0.699H + 0.617E - 0.634N + 0.571BG

Predictor	Coef	Stdev	t-ratio	p
Constant	0.8476	0.1127	7.52	0.000
CF	2.0023	0.2966	6.75	0.000
A	0.8267	0.1724	4.80	0.000
H	-0.6986	0.1118	-6.25	0.000
E	0.6173	0.1359	4.54	0.000
N	-0.6339	0.2401	-2.64	0.025
BG	0.5715	0.2061	2.77	0.020

s = 0.2174 R-sq = 97.1% R-sq(adj) = 95.4%

Analysis of Variance

SOURCE	DF	SS	MS	F	p
Regression	6	15.9576	2.6596	56.26	0.000
Error	10	0.4728	0.0473		
Total	16	16.4304			

SOURCE	DF	SEQ SS
CF	1	8.6230
A	1	3.6959
H	1	2.3117
E	1	0.7730
N	1	0.1905
BG	1	0.3634

Unusual Observations

Obs.	CF	PAR3	Fit	Stdev.Fit	Residual	St.Resid
14	1.00	4.6600	4.6600	0.2174	0.0000	* X

X denotes an obs. whose X value gives it large influence.

Eigenvalues and VIF for PAR3

2.40581 1.37293 0.80669 0.61600 0.18658 0.10976 0.03277

VIF = 73

Output B-5, Number Questions Asked by the Unit (PAR5)

PAR5 = - 0.938 + 1.16 C + 0.493 L + 0.474 AE

Predictor	Coef	Stdev	t-ratio	p
Constant	-0.93757	0.03297	-28.43	0.000
C	1.1594	0.1189	9.75	0.000
L	0.4928	0.1189	4.14	0.001
AE	0.4738	0.1081	4.38	0.001

s = 0.1189   R-sq = 97.4%   R-sq(adj) = 96.7%

Analysis of Variance

SOURCE	DF	SS	MS	F	p
Regression	3	6.7556	2.2519	159.33	0.000
Error	13	0.1837	0.0141		
Total	16	6.9393			

SOURCE	DF	SEQ SS
C	1	5.6138
L	1	0.8703
AE	1	0.2715

Unusual Observations

Obs.	C	I	Fit	Stdev.Fit	Residual	St.Resid
3	1.00	0.8841	0.6957	0.1030	0.1884	3.17RX
12	0.00	0.2174	0.0290	0.1030	0.1884	3.17RX
13	0.00	-0.6522	-0.4638	0.1030	-0.1884	-3.17RX
14	1.00	1.0000	1.1884	0.1030	-0.1884	-3.17RX

R denotes an obs. with a large st. resid.
X denotes an obs. whose X value gives it large influence.

Eigenvalues and VIF for PAR5

1.62752   1.00000   0.22344   0.05288
VIF = 31

Output B-6, Discussion Amongst the Unit (PAR4)

PAR4 = 0.200 - 0.200 E + 1.00 N + 0.800 AF - 0.800 FG

Predictor	Coef	Stdev	t-ratio	p
Constant	0.2000	0.1155	1.73	0.109
E	-0.2000	0.1495	-1.34	0.206
N	1.0000	0.2080	4.81	0.000
AF	0.8000	0.2828	2.83	0.015
FG	-0.8000	0.3511	-2.28	0.042

s = 0.2582 R-sq = 77.3% R-sq(adj) = 69.8%

Analysis of Variance

SOURCE	DF	SS	MS	F	p
Regression	4	2.72941	0.68235	10.24	0.001
Error	12	0.80000	0.06667		
Total	16	3.52941			

SOURCE	DF	SEQ SS
E	1	0.01426
N	1	2.18182
AF	1	0.18713
FG	1	0.34620

Unusual Observations

Obs.	E	PAR4	Fit	Stdev.Fit	Residual	St.Resid
5	0.00	1.0000	1.0000	0.2582	0.0000	* X
16	0.00	1.0000	0.2000	0.1155	0.8000	3.46R

R denotes an obs. with a large st. resid.
X denotes an obs. whose X value gives it large influence.

Eigenvalues for PAR4

2.88174 0.75468 0.37030 0.19047 0.03524
VIF = 96

Output B-7, Unit Specified *Solutions Developed* (DuD)

DuD = 0.326 + 2.73 A + 1.75 D - 1.53 F - 1.79 G + 2.39 L - 2.06 M

Predictor	Coef	Stdev	t-ratio	p
Constant	0.3258	0.1910	1.71	0.119
A	2.7252	0.3825	7.12	0.000
D	1.7488	0.3588	4.87	0.000
F	-1.5309	0.4667	-3.28	0.008
G	-1.7890	0.3703	-4.83	0.000
L	2.3945	0.4703	5.09	0.000
M	-2.0618	0.3521	-5.86	0.000

s = 0.4323 R-sq = 92.2% R-sq(adj) = 87.5%

Analysis of Variance

SOURCE	DF	SS	MS	F	p
Regression	6	22.1315	3.6886	19.74	0.000
Error	10	1.8685	0.1868		
Total	16	24.0000			

SOURCE	DF	SEQ SS
A	1	12.6212
D	1	0.0005
F	1	0.0833
G	1	0.0976
L	1	2.9208
M	1	6.4081

Unusual Observations

Obs.	A	DuD	Fit	Stdev.Fit	Residual	St.Resid
11	0.00	1.000	0.286	0.264	0.714	2.09R

R denotes an obs. with a large st. resid.

Eigenvalues and VIF for DuD

2.66848	1.05408	0.84912	0.41545	0.28066	0.11595	0.03039
						VIF = 88

Output B-8, Total *Solutions Developed* (DtD)

DtD = 1.63 + 1.78 C + 1.17 F

Predictor	Coef	Stdev	t-ratio	p
Constant	1.6322	0.2598	6.28	0.000
C	1.7816	0.7082	2.52	0.025
F	1.1724	0.5379	2.18	0.047

s = 0.9160   R-sq = 50.6%   R-sq(adj) = 43.5%

Analysis of Variance

SOURCE	DF	SS	MS	F	p
Regression	2	12.0176	6.0088	7.16	0.007
Error	14	11.7471	0.8391		
Total	16	23.7647			

SOURCE	DF	SEQ SS
C	1	8.0314
F	1	3.9862

Unusual Observations

Obs.	C	DtD	Fit	Stdev.Fit	Residual	St.Resid
3	1.00	4.000	3.414	0.701	0.586	0.99 X
14	1.00	4.000	4.586	0.701	-0.586	-0.99 X

X denotes an obs. whose X value gives it large influence.
Regression Analysis

Eigenvalues and VIF for DtD

0.635384	0.333333	0.054271
		VIF = 12

Output B-9, Unit Specified *Solutions Planned* (DuP)

DuP = 0.481 + 0.522I + 1.47JL - 1.41CF - 0.112F + 0.0479B

Predictor	Coef	Stdev	t-ratio	p
Constant	0.48148	0.01835	26.24	0.000
I	0.52166	0.01742	29.94	0.000
JL	1.46950	0.03937	37.33	0.000
CF	-1.40826	0.04356	-32.33	0.000
F	-0.11231	0.02244	-5.01	0.000
B	0.04793	0.01708	2.81	0.017

s = 0.02925 R-sq = 99.8% R-sq(adj) = 99.7%

Analysis of Variance

SOURCE	DF	SS	MS	F	p
Regression	5	5.0494	1.0099	1180.30	0.000
Error	11	0.0094	0.0009		
Total	16	5.0588			

SOURCE	DF	SEQ SS
I	1	3.3837
JL	1	0.7238
CF	1	0.9165
F	1	0.0187
B	1	0.0067

Unusual Observations

Obs.	I	DuP	Fit	Stdev.Fit	Residual	St.Resid
3	0.88	1.00000	0.99059	0.02911	0.00941	3.32RX
12	0.22	2.00000	2.00000	0.02925	0.00000	* X
14	1.00	1.00000	1.00000	0.02925	0.00000	* X

R denotes an obs. with a large st. resid.
X denotes an obs. whose X value gives it large influence.

Eigenvalues for DuP

2.85940 1.62915 0.66770 0.42361 0.09194 0.03445
VIF = 83

Output B-10, Total *Solutions Planned* (DtP)

DtP = 1.69 + 0.167 B - 2.43 C - 0.326 F + 1.84 I

Predictor	Coef	Stdev	t-ratio	p
Constant	1.6917	0.1211	13.97	0.000
B	0.16715	0.06162	2.71	0.019
C	-2.4295	0.2184	-11.12	0.000
F	-0.32636	0.08422	-3.87	0.002
I	1.8405	0.1231	14.96	0.000

s = 0.1060 R-sq = 97.3% R-sq(adj) = 96.4%

Analysis of Variance

SOURCE	DF	SS	MS	F	p
Regression	4	4.9241	1.2310	109.65	0.000
Error	12	0.1347	0.0112		
Total	16	5.0588			

SOURCE	DF	SEQ SS
B	1	1.3445
C	1	0.5143
F	1	0.5538
I	1	2.5114

Unusual Observations

Obs.	B	DtP	Fit	Stdev.Fit	Residual	St.Resid
12	1.00	2.0000	1.9326	0.1042	0.0674	3.46RX
13	0.00	0.0000	0.1651	0.0700	-0.1651	-2.08R

R denotes an obs. with a large st. resid.

Eigenvalues for DtP

2.85940	1.62915	0.66770	0.42361	0.09194	0.03445
					VIF = 83

Output B-11, % Discussion Time (TIME1)

TIME1 = 292 - 406C + 23.9D - 27.2E + 27.6H + 228I - 10.7K + 24.4O
- 18.1AB - 218AL - 85.1FG - 446HL

Predictor	Coef	Stdev	t-ratio	p
Constant	292.35	72.58	4.03	0.010
C	-405.9	141.1	-2.88	0.035
D	23.922	8.128	2.94	0.032
E	-27.16	11.35	-2.39	0.062
H	27.580	7.894	3.49	0.017
I	228.22	78.30	2.91	0.033
K	-10.745	8.262	-1.30	0.250
O	24.44	10.38	2.36	0.065
AB	-18.13	14.42	-1.26	0.264
AL	-218.3	100.6	-2.17	0.082
FG	-85.12	25.72	-3.31	0.021
HL	-446.0	187.7	-2.38	0.063

s = 12.01   R-sq = 86.2%   R-sq(adj) = 55.7%

Analysis of Variance

SOURCE	DF	SS	MS	F	p
Regression	11	4494.5	408.6	2.83	**0.130**
Error	5	721.2	144.2		
Total	16	5215.8			

SOURCE	DF	SEQ SS
C	1	34.2
D	1	0.1
E	1	68.5
H	1	1001.7
I	1	621.9
K	1	816.2
O	1	361.1
AB	1	10.6
AL	1	0.0
FG	1	766.0
HL	1	814.2

* NOTE * C is highly correlated with other predictor variables
* NOTE * I is highly correlated with other predictor variables
* NOTE * AL is highly correlated with other predictor variables

Unusual Observations

Obs.	C	TIME1	Fit	Stdev.Fit	Residual	St.Resid
3	1.00	85.00	85.00	12.01	0.00	* X
12	0.00	90.00	90.00	12.01	0.00	* X
13	0.00	52.00	52.00	12.01	0.00	* X
14	1.00	71.00	71.00	12.01	0.00	* X

X denotes an obs. whose X value gives it large influence.

APPENDIX C

CURRENT AAR SYSTEMS IN TRAINING SIMULATIONS

Small Unit Simulation Training Systems

Currently, the Army's small unit simulation training systems are SIMNET and CCTT. Both train platoon and company collective tasks in a virtual environment. SIMNET is the legacy system and CCTT, its replacement, is the first of a number of virtual training systems that will form the Combined Arms Tactical Trainer (CATT). In completion, the CATT will consist of the: CCTT for mechanized infantry, armor, and cavalry units; Aviation Combined Arms Tactical Trainer (AVCATT) for Army aviation units; Fire Support Combined Arms Tactical Trainer (FSCATT) for field artillery and mortar units; Air Defense Combined Arms Tactical Trainer (ADCATT) for air defense units; and Engineer Combined Arms Tactical Trainer (ENCATT) for engineer units. (STRICOM, 1996a) Each training system will be Distributed Interactive Simulation (DIS) compliant and consist of networked, high fidelity, manned simulators, Semi-Automated Forces (SAF), support workstations, computer networks and protocols, and an AAR system. (STRICOM, 1996b)

AAR Systems in Training Simulations

Larry Meliza's research report, Standardizing Army After Action Review Systems (1996), is the most complete and thorough source reviewing Army AAR systems and efforts for small unit training systems. Meliza conducted the research to support development of the needs and capabilities for the Standard Army After Action Review System (STAARS). To complete this research, he reviewed the relevant literature, published and unpublished findings of three Army-wide AAR conferences, and examined two ongoing AAR system development efforts in relation to a legacy AAR system. The Army Training and Analysis Feedback System (ATAFS) and the Simulation Training Integrated Performance Evaluation System (STRIPES) were compared to the development of the Unit Performance Assessment System (UPAS) to clarify the needed capabilities of STAARS. Many of Meliza's findings were used by the National Simulation Center (NSC) as capability specifications and rationale for the STAARS Operational Requirements Document (ORD). (Meliza, 1996a, viii)

The review of Meliza's research, UPAS, ATAFS, STRIPES, the CCTT AAR system, and STAARS, reveals that these systems are primarily concerned with reducing the workload associated with preparing the AAR and formatting the information products that result from the preparation. In other words, these systems focus on automating data collection, compilation, and display to reduce the amount of time it takes a trainer/AAR leader to prepare an AAR for presentation. In this sense, these AAR systems are specifically designed to ensure the AAR's timeliness through preparation efficiency.

The need for preparation efficiency is driven by two reasons. As Meliza points out, lower echelon AARs precede higher echelon AARs so that the results of the first can be used as input for the second. Thus, to start higher echelon AARs in a timely manner, lower level AARs must be completed as soon as possible. The Mounted Warfare Training Simulation Center at FT Knox tries to begin platoon AARs 10 minutes after the end of a training exercise. (Meliza, 1996a, 27) Another reason to rush preparation is that units may need to conduct subsequent exercises on the trainer and therefore need the AAR system to collect data for their exercise. Currently, none of the AAR systems have the requirement to nor can they display a presentation for a previous exercise while collecting data from a separate running exercise.

It is apparent from each AAR system's purpose statement and system description that none is designed to directly improve effectiveness with respect to discussion participation and timely learning reinforcement. (US ARI, 1997, BCTD, 1996a, LORAL/Army IDT, 1996, LB&M, 1996, LORAL, 1994, and Meliza et al., 1992a) However, these systems do impact AAR effectiveness with respect to conducting a timely AAR and discussion focus. Well designed data displays will aid units in determining what is critical and what happened. The more quickly ground truth can be represented, the faster the unit can focus on why it happened and how to do it better. This capability greatly enhances the focus of discussion to solve performance problems.

Except for STAARS, none of the systems propose tools to aid in determining how to perform a task better. STAARS is requiring the capability to: "translate lessons

learned from the CALL [Center for Army Lessons Learned], Battle Command Battle Lab experiments, CTC rotations, and other sources into leader development and collective training concepts, methods and strategies and revised doctrine and/or tactics, techniques, and procedures." (BCTD, 1996a, paragraph 3.a.2.a.6) Although this capability is not identified for use during the AAR, it is conceivable that if information is collected, then it could be stored and updated for use in the AAR also.

The retraining of specific tasks is also not considered to be needed as an AAR system capability. None of the systems require a capability to reinforce what was learned during the AAR. This is understandable given that the popular interpretation of the training model paradigm concludes the cycle with the AAR. As stated before, this must change in order to reinforce the learning that occurs during the AAR.

STAARS

The principal proponents for STAARS are the Deputy Chief of Staff for Training (DCST) of the Training and Doctrine Command (TRADOC) and the NSC. They are charged to develop a standard AAR system to "support training, mission rehearsals, and research/experimentation at all echelons from individual through Echelons Above Corp (EAC) with packages of AAR products standardized by echelon and Battlefield Operating System (BOS)." (BCTD, 1996a) The intent for STAARS is that it satisfy the AAR needs across the Training Exercises and Military Operations (TEMO), Research, Development, and Acquisition (RDA) community, and Advanced Concepts and

Requirements (ACR) domains to reduce system redundancy and provide standard formats for data collecting and storage for training, testing, evaluating, and analyzing data to support the total Army. (BCTD, 1996a)

The STAARS concept supports training as a three tier system. The first tier would provide automated, standard AAR products derived from "the commander's Mission Essential Task List (METL) for training events."[46] (BCTD, 1996a) This automates preparation for the AAR leader by automatically producing the AAR products associated with the tasks to be trained. The second tier provides automated AAR products with a selection menu for advanced or additional analysis. (BCTD, 1996a) This tier would be mostly used by the R&D community for statistical analysis and verification, validation, and accreditation. The last tier provides the user the ability to build customized AAR products. (BCTD, 1996a) The primary output of the STAARS is the standardized training exercise data that will be stored in the Army Training Digital Library (ATDL). (BCTD, 1996a)

Currently, STAARS exists conceptually on paper as a mission needs statement and a plan of action. For STAARS, success as a system is defined as achieving: the standardization of all data elements IAW the DoD Data Dictionary; the sharing of these standardized data elements among the ACR, RDA, and TEMO domains; access of data across the total Army; a reduction of training and event evaluation and assessment time;

[46] BCTD and NSC improperly use the term METL here. A unit's METL is an "unconstrained [with respect to resources] statement of tasks required to accomplish wartime missions." (DA, FM 25-101, 2-2) Trying to focus the evaluation and assessment on the whole METL for each training exercise is unrealistic and is an extremely inefficient means of improving performance.

and the use of the standardized data for analysis in support of the ACR's, RDA's, and TEMO's purposes. (BCTD, 1996a) Taking this end state by itself, one may think that STAARS only addresses information management problems. The only mention of the training management perspective is STAARS's aim to make event evaluation and assessment time more efficient. The STAARS Action Plan does not address effectiveness, of anything.

A major problem that STAARS is seeking to remedy is the standardization of AAR information. Currently, AAR products are not standardized across or within live, virtual, or constructive training systems. This non-standardization of products impact the AAR and simulation integration. If multiechelon training is being conducted on live and virtual training systems, there is no way to integrate the AARs. Furthermore, the same problem is present for single echelon training on two different training systems of the same simulation category. For example, two platoons performing the same mission on CCTT and SIMNET will each receive AAR products that differ in format, content, and level of detail.

None of the BCTD or NSC documents explicitly outline a goal or purpose for AAR aids and their use. (BCTD, 1996b; BCTD, 1996a; BCTD, 1995; and NSC, 1995) Given the literature review and personal experience, AAR products should guide/focus the AAR, efficiently transmit relevant information to the audience, and record the lessons learned. Collectively, the products should show the critical training events, results of those events, and the logical, cause-and-effect linkage between training event and lessons

learned. Successful distributed training not only requires a common understanding and perception of the battlefield amongst linked systems, but also requires a common understanding and perception of the feedback resulting from the training. If this understanding and perception are uncommon, then two distributed groups may not have the same effectiveness or battlefield situation considerations to assess and improve performance. However, if they are each able to define a problem and identify the same factor and variable relationships, then steps to improve performance can be orchestrated with respect to their units and each other.

Physically, STAARS exists as 101 standard information formats for AAR products that have been developed and published in the first version of the STAARS <u>AAR Handbook</u>. (BCTD, 1995) There are five standard types of formats that STAARS lists: the battle summary, battle set, sketch, statistical report, and word slide. The battle summary is a video animation showing friendly and enemy force maneuver. The battle set is a single frame or snapshot from the battle summary animation. The sketch is a user created product that displays a concept, an aspect of the battle, or doctrinal principle. The statistical report is a graph or chart developed from exercise data, and the word slide is a user created slide of written text. (BCTD, 1995)

Surveying the content or these product formats reveals that they were not developed for the information needs of small unit training feedback. Instead, these products focus on information requirements of brigade and higher level units. An example of this shortcoming can be seen by reviewing the required maneuver AAR

products for information concerning a specific engagement. Given that a platoon and enemy force engage in a fire fight, the resulting AAR products are listed in Table C-1, STAARS AAR Products Supporting Maneuver.

Even if the STAARS could track and report individuals and vehicles to the extent that all AAR products could be made to apply to all echelons, the collection of products still fails to show which individual shot another individual at a certain location and point in time. The platoon and company AAR products must portray enemy and friendly actions/units in greater levels of detail. Specifically, the resolution level must include individual activities and communication transmissions.

In fact, the AAR products are more suited to showing unit trends over an extended period of time or multiple engagements. Each is designed to represent an aggregation of units or statistics. The point is that STAARS does not support training below brigade level. Although it may eventually evolve a capability to do so, its current priority is to support higher echelon training and R&D efforts first. If STAARS is to be the Army's baseline AAR specification, a thorough analysis to define the standardized platoon and company AAR requirements is needed.

At small unit levels, STAARS does not capture sufficient information for effective performance feedback of combat operations/actions. CCTT AAR, STRIPES and ATAFS all have the capability to capture information pertaining to the anatomy of a fire fight. Important information concerning who shot first, how effective was the gunnery of

Table C-1, STAARS AAR Products Supporting Maneuver

AAR Product (& Type)	Description	Applicable Echelon
Movement Animation (Battle Summary)	series animation of a 2-D map showing specific units moving during a specified time period	All
Maneuver Forces: Available, Committed, Engaged (Statistical Report)	line graph showing units available, committed, and engaged in the area	Company – Division
Maneuver Battle Sets (Battle Set)	two dimensional map display of units and their locations	All
Weighting the Main Effort (Statistical Report)	bar graph showing the distribution of combat power between the main effort units and supporting effort units	Brigade and higher
Degradation of Forces (Statistical Report)	horizontal line chart depicting the statistical degradation of friendly and enemy forces	All
Movement Time Lines (Statistical Report)	horizontal bar graph displaying the variance between planned and actual movement times	Battalion and higher
Comparison of Forces - Main Effort (Statistical Report)	vertical bar graph comparing relative friendly and opposing force levels in a specific location and time period of the battlefield	All
Use of Reserve (Sketch)	timeline showing the status of the designated reserve units	Battalion – Division
Counterreconnaissance Effectiveness (Statistical Report)	vertical bar graph showing the total number of OPFOR reconnaissance assets, the number detected, and the number destroyed	All
Fratricide (Battle Set)	two dimensional map display of unit locations and the fratricide results	All

(BCTD, 1995, 21 through 36 and 114)

individual vehicles, when did the enemy see the Blue force and when did the Blue force see the enemy are important elements that need to be discussed during an AAR. During live training at the CTCs, this level of detail is demanded to support crew, squad, platoon, company, and battalion AARs. None of the STAARS products require or present information at this level of detail.

The most efficient and effective method of deciding what standard format should be used for an AAR product is to conduct a cognitive task analysis (Appendix A, Theoretical Foundations, and Anderson, 1993) of what the trainee must perform. To date, this has not been done to the required level of detail. The level of detail needed is such that each task and subtask can be described by a production system model. This forces the identification of measurable inputs and outputs that are germane to the task. These are the inputs and outputs that then need to be reported on the standardized AAR aid. Given the MTPs, one fourth of the work is already done. The MTPs identify the tasks that need to be broken into primitive subtasks and then broken into declarative condition chunks and production rules. Meliza hints at this but does not elaborate the need. (Meliza, 1996a, 46) This would eliminate the trial and error efforts of documenting measures of performance in simulation training systems (Meliza, 1996a, 54)

An additional benefit of a detailed cognitive task analysis is that the AAR aid will directly address the productions and declarative misconceptions that caused poor

performance. These are exactly the elements that must be retrained. Hence, the AAR becomes a planning session for retraining or future training.[47]

STAARS is not scheduled to be funded until the 1998 fiscal year. At that time, the NSC, the BCTD, Battle Command Training Program (BCTP), and Army field commanders will evaluate contract proposals for the system. STAARS will then be built over a six year period and is scheduled for fielding in 2004. (BCTD, 1996a)

SIMNET and UPAS

As stated before, SIMNET was purposefully built without an AAR system. (Alluisi, 1991) A review of the sources that recount AAR system capabilities and history reveals two notes concerning the absent AAR component in SIMNET: first, the design of AAR systems was modular so that they could be unplugged from the training system and upgraded, and second, SIMNET became a test vehicle for AAR system development. (Meliza, 1996, Bessemer et al., 1995, Rankin et al., 1995, and Meliza et al., 1992b)

The modular system design is still a capability that is sought by design engineers. In an internal memorandum calling for a collective AAR system research and development effort, the Program Manager (PM) of CATT emphasized the need for a common DIS compliant AAR system with an "open architecture [so that] specific applications could be 'plugged in' to the core [training] system." (STRICOM, 1996d)

[47] The term "retraining" denotes the training that occurs immediately after a training exercise to correct deficiencies.

UPAS was the initial AAR system development effort for SIMNET. As such, it established the standard of needed components and system capabilities for subsequent AAR systems. It is a personal computer (PC) based system that assists trainers and researchers in analyzing unit performance. (Meliza et al., 1992a, 1) Thus, UPAS was a tool the trainer could use to collect and present information for the AAR or training assessment. At the same time, features were included that facilitated scientific research and analysis. (Meliza et al., 1992a, 1) Two limitations of UPAS are: 1) all exercise data must be collected before its analysis capabilities can be utilized, and 2) the system cannot monitor radio communications. (Meliza et al., 1992b, 27)

The components of UPAS are: the data collector that collects all pertinent data broadcast over the network; PC with internal tape drive and printer for manipulation of data stored on a relational database; and large television monitor to display exercise replay segments with "stealth" and "out the window" views, Plan View Display (PVD), Battle Flow Chart, Battle Snapshots, Exercise Timeline, and user created graphs and tables. (Meliza et al., 1992b, 5, 6, and 35 to 36, and Meliza et al., 1992a, 1, 2, and A-1)

UPAS's format designs of the PVD, Battle Flow Chart, Battle Snapshots, and Exercise Timeline AAR aids were adapted by ATAFS and STAARS. These aids were developed and tested with UPAS. (Meliza et al., 1992b) The PVD is a two dimensional map view of a specified area with operational graphics and unit icons superimposed on a map grid and topographical features. The PVD has adjustable magnification settings so a larger or smaller area can be displayed. (Meliza et al., 1992b, 22) The Battle Flow Chart

is an animated replay of a specified area and time period that shows individual vehicle as well as unit movement, relative positioning, operational graphics, map grid marks, and topographical features. (Meliza et al., 1992b, 23) The Battle Snapshot is another two dimensional, animated view of a specified area. It shows an instance of a Battle Flow Chart. Hence, previous movement and direction of travel are not readily apparent from this aid. (Meliza et al., 1992b, 24) The fourth aid is the Exercise Timeline. It is a "tool for looking at temporal coordination of movement, control measures, and firing events." (Meliza et al., 1992b, 25)

CCTT AAR System

The CCTT AAR workstation consists of: a PVD that can display both two and three dimensional replay of the exercise using "stealth" or "out-the-window" views as well as display graphs, tables, and word (text) slides; debriefing display that is a color projection screen measuring 68 by 92 inches; visual display that provides a 120 by 30.5 degree field of view; control console to log, reduce, and analyze all network data; printer to make paper copies of displayed information; radios and voice recorder to collect and record all voice communications traffic; and a VHS tape recorder to record specified exercise video clips and the corresponding voice communications. There are five workstations to accommodate data collection of five simultaneous and separate training exercises. (LORAL/Army IDT, 1996, 66 through 73, 167, and A-35 to A-36)

An attractive feature of the CCTT system is the capture of player and trainer voice communications. During exercise execution, the workstation operator can communicate on one of four exercise radio channels while the system records all voice communications on all exercise channels. Furthermore, the operator can make time-stamped voice annotations on a separate channel during replay. (LORAL/Army IDT, 1996, 72) Thus, the AAR leader can annotate discussion points with verbal comments, textual comments, or both.

CCTT's AAR console has preset statistical analysis capabilities that may be employed after the exercise when all the data is collected. The workstation operator can choose to output any of 12 statistical reports once the analysis is complete. However, he may not customize the statistical analysis or products. (LORAL/Army IDT, 1996, 71 and 72)

During the conduct of the AAR, the system requires a workstation operator to run the AAR presentation. The operator can not create nor use just any combination of video, audio, or text to support the presentation. (STRICOM, 1996d) He is limited to what the system is programmed to do.

Currently, the take home package that CCTT produces consists of a VHS tape of the information ported to the debrief screen. (STRICOM, 1996d) There are no mechanisms to record the audience's or AAR leader's comments/discussion during the AAR. Planned improvements include an additional VHS recorder per workstation to record these comments. Other forecasted improvements are to include capabilities that

will support the production of a video and paper copy take home package that incorporates media and data from all or any of the training exercises conducted during a specified time period. (STRICOM, 1996d)

ATAFS

The ATAFS is a workstation consisting of a 35 inch television for exercise replay and display of AAR aids; PC with external tape drive and printer to monitor the storage of unit activity data, VHS video recorder to record the AAR presentation; and digitizing tablet for inputting operational graphics prior to the exercise. (LB&M, 1996, 2) There are four features that set ATAFS apart from the other systems. The first is that it employs an expert knowledge base to automatically create AAR aids that are very similar to those in UPAS. The second feature gives the user the capability to create custom AAR aids before, during, or after the exercise. The third records voice communications during the exercise and can synchronously replay both video and voice actions. The fourth capability is that whatever is presented on the large TV screen during the AAR is recorded by the video recorder for the take home package.

The automatic creation of AAR aids in ATAFS is governed by an expert system that uses tactical events as condition triggers for the recording of predetermined data (LB&M, 1996) These capabilities reduce the AAR leader/trainer AAR preparation workload. The ATAFS automatically generates AAR training aids and discussion points by monitoring and analyzing network data and responding to O/C interactive

commands/prompts. Mission based rule sets control the automatic generation of AAR products for generic and routine combat actions. (LB&M, 1996) This frees the O/C to monitor the critical actions that are unique to the training conditions – unique specified and implied tasks, the enemy array, terrain effects, friendly force status, and time available. Hence, the O/C has more time available to analyze the cause and effect relationship between an action and results. Current improvements being developed are to expand the knowledge base to monitor more collective tasks and improve the system's flexibility and responsiveness to both AAR preparation and exercise control use. (Brown, 1996)

The digitizing tablet and work station allow the O/C to select the desired AAR product and its format for presentation. (LB&M, 1996, 1-16) The ATAFS format types match the required STAARS product format types as shown by Table C-2, ATAFS and STAARS Product Types. Unlike any of the other AAR systems, ATAFS can combine the Word Slide aid with any of the other aids. Hence, ATAFS does have some presentation flexibility. It has the ability to capture actions and sequences of actions and present them in any of its available formats. The O/C can select or reconfigure the product format to make the point of discussion clear to the audience. However, it can not employ multimedia presentation methods.

Table C-2, ATAFS and STAARS Product Types

ATAFS		STAARS
Plan View Animation	=>	Battle Summary
Snapshot, Battle Flow, and Fire Fight	=>	Battle Sets and Sketches
Statistical Aids	=>	Statistics Reports
Word Slides	=>	Word Slides

As with the other systems, the presentation medium for the ATAFS AAR is the TV screen. (LB&M, 1996, 1 through 25) The TV screen can display both two and three dimensional replay of the exercise using "stealth" or "out-the-window" views as well as display graphs, tables, and word (text) slides. Of these last three aids, ATAFS can display a combination. Since the VCR records everything on the TV, the AAR presentation is captured and ready for the unit at the end of the AAR. However, participant comments or AAR leader remarks are not automatically included in the package.

Essentially, the AAR and take home package that ATAFS prepares and creates, respectively, is a combination of AAR leader and expert system lecture notes with supporting slides and video clips. Both are void of participant input or any elaboration of what happened, why it happened, and how to do it better. ATAFS does give the AAR leader more time to think about and prepare the AAR by automating routine tasks. Hence, this could result in discussion points with supporting documentation being more

carefully thought out and presented. ATAFS does help the AAR leader in preparation of the AAR more than the other systems do.

STRIPES

STRIPES consists of a protocol data unit (PDU) scanner to collect data, data logger to store data, and a two dimensional (2D) plan view display integrated with a three dimensional (3D) stealth view display for exercise replay. (LORAL, 1994) The strongest feature of STRIPES is its capability to archive exercise data. An Oracle relational database engine allows the user to filter data and perform a number of statistical analyses. These analyses can then be presented via graphs and tables on the 2D display or printed to paper. (Hayes, J. [AcuSoft Inc.], personal communication, 13 May 1996)

Exercise replay is accomplished with the 2D/3D viewer and is comparable to the replay capabilities of CCTT and ATAFS. Unlike ATAFS, the preparation of AAR products can not begin until the exercise data is logged. However, with a proficient workstation operator, STRIPES has the capability to analyze and present different aspects of the exercise data during the AAR. Hence, the operator could take data analysis commands from participants during the AAR. This would allow clarification of performance outcomes or further analysis beyond what was presented by the AAR leader.

Like the AAR aid preparation, take home package generation in STRIPES must occur after the exercise. The database engine and workstation environment does speed the process of collecting and combining specific data elements to support written

observations. However, this requires a skilled database operator and someone to identify which data elements need to be analyzed.

STRIPES's attractive feature is its ability to integrate real world training data with the training execution data and then store the information for easy statistical analysis. While this feature may serve operational research needs, it does not enhance the feedback given the trainee immediately following the training. Potentially, STRIPES may meet the STAARS requirement to digitize the training exercise for storage in the Army Training Digital Library (ATDL). (BCTD, 1995, 5 through 10) However, STAARS has not described these requirements in detail and future technology developments may meet this need more efficiently and/or effectively.

APPENDIX D

IMPLEMENTATIONS OF INQUIRY THEORY

There are two remarkable demonstrations of the effect that Inquiry theory has on learning; Valerie J. Shute's and Robert Glaser's *Smithtown* (Shute and Glaser, 1990) and Alan Lesgold's, Gary Eggan's, Sandra Katz's, and Govinda Rao's *Sherlock* (Towne and Munro, 1991, and Lesgold et al., 1992) Both of these are simulation-based systems designed to use inquiry strategies for domain specific knowledge acquisition. Each found that inquiry skills dramatically increased the student's ability to remember and apply the domain knowledge.

Smithtown

Smithtown is an intelligent tutoring system that systematically guides the student's discovery of microeconomics. The system has two goals. The first is to aid the student in mastering scientific inquiry skills – becoming more systematic and goal oriented in the discovery of rules and theories. The second is to impart microeconomics subject content to the student. (Shute and Glaser, 1990, 51 to 53) Shute and Glaser found that the "most optimum learner behaviors … are systematic, hypothesis-driven activities." (Shute and Glaser, 1990, 74) In other words, the students who learned the

most, as measured by pretest – posttest change, about microeconomics learned and applied inquiry skills. Relative to the pretest, those who did poorly on the posttest resisted the guidance of the intelligent tutor in Smithtown or were in the control group that did not use Smithtown. (Shute and Glaser, 1990, 63)

Shute and Glaser identified and addressed two problems when developing the instruction tutor for induction reasoning and hypothesis testing. These problems are that "many learners can induce regularities/patterns but do not treat them as hypotheses to be tested" and when they do test a hypothesis, many use faulty methods or procedures that do not guarantee reasonable or relevant conclusions. (Shute and Glaser, 1990, 52) These problems were the impetus for the goal to teach effective inquiry skills.

To accomplish the goal, Smithtown constantly maintains and monitors a model of student actions. The system is able to determine student process errors by comparing student actions and sequences of actions to an expert model of inquiry rules/theories. This expert model is stored in a procedural knowledge base of inquiry productions. (Shute and Glaser, 1990, 53, and Williams, 1996a) The system makes the student aware of the elements of inquiry skill and then allows him to learn them through practice. For example, if the student conducts an experiment to determine what factors affect a dependent variable and chooses to vary two or more factors without reviewing baseline data, then the tutor recommends that he review the data and vary only one factor at a time. (Shute and Glaser, 1990, 55) Hence, the student's application of inquiry methods are diagnosed.

Students manipulate variables, observe effects, and organize information to explore the microeconomics principles embedded in Smithtown. (Shute and Glaser, 1990, 56) The system prompts the student in two types of systematic investigation: "1) explorations – observing and obtaining information to generate hypotheses about the microeconomics concepts and laws; and 2) experiments – a series of student actions conducted to confirm or differentiate hypotheses." (Shute and Glaser, 1990, 56)

Smithtown also diagnoses the quality of the student's understanding of the domain knowledge. The system stores the economics factors and their relationships in a declarative knowledge base. By requiring the student to adhere to a specific interaction format, the tutor can relate student input to factor relationships of supply and demand. The student's generalized rule/theory can be assessed for completeness by comparison to the domain knowledge base. For example, if the student makes a correct hypothesis about which factors affect a dependent variable, then the system acknowledges the discovery and elaborates the rule/theory further to the student. (Shute and Glaser, 1990, 53)

Smithtown is remarkable for instruction efficiency. The performance difference between students instructed by Smithtown for 5 hours and students instructed by university economics professors for 11 hours were not statistically significant. (Shute and Glaser, 1990, 67 and 73) With less than half the instruction time of students in an undergraduate economics course, students using Smithtown performed at a comparable level on economics tests.

In the Smithtown experiments, Shute and Glaser were able to determine what made students more or less successful. The result was a list of the behaviors exhibited by successful students, as determined by pretest–posttest change, that had the most significant statistical effect. These behaviors are listed in order of significance in Table D-1, Significant Inquiry Behaviors. Also listed in the table, are Collins' Inquiry theory strategies that correspond to the significant behaviors of Smithtown students.

With respect to Collins' strategies, Smithtown is predicated on and implements the *questioning authority* strategy (Chapter IV, pg. 165). By not allowing the student to rely upon the teacher or intelligent tutor to supply the answer, it forces the student to think and experiment on his own. It rewards logical sequences of behaviors and highlights and corrects illogical behaviors.

The intelligent tutor in Smithtown reinforces student behavior that corresponds to Collins' strategies that the student uses to acquire domain knowledge. Specifically, it requires students to: *form hypotheses*, *generate hypotheses*, *test hypotheses*, *vary cases systematically*, and *consider alternative predictions* (Table D-1, Significant Inquiry Behaviors in Smithtown).

Table D-1, Significant Inquiry Behaviors in Smithtown

Significant Behavior	Description	Corresponding Inquiry Theory Strategies
1. Generalization	Testing developing economic beliefs across markets – generalizing a concept across related and unrelated goods.	Generating hypotheses Testing hypotheses
2. Complexity of experiment	Number of times a specific factor was varied and the average number of connected actions associated with an experiment.[48]	Considering alternative predictions
3. Systematic variable changes	Number of variables changed per experiment iteration (step) to discover interrelationships.	Varying cases systematically => Testing hypotheses
4. Adequate data collection	Number of times sufficient data was gathered before generalization.	=> Forming hypotheses
5. Planning an experiment	Number of times connected actions occurred that had been specified (planned) beforehand – planned variable changes that were performed.	[feedback measure not accounted for by Collins]
6. Predicting experimental outcomes	Number of specific predictions made divided by the number of general hypotheses made.	Forming hypotheses
7. Notebook entries	Number of relevant notebook entries divided by the total number of notebook entries.[49]	[feedback measure not accounted for by Collins]

[48] Reference behavior # 2; connected actions are actions associated with defining a set of factors and their interrelationships.

[49] Reference behavior # 7; relevant notebook entries refers to the entries associated with the variables specified in the plan of the experiment. Overall, successful students made more notebook entries than less successful students. Additionally, those entries were relevant to the focus of their investigation. (Shute and Glaser, 1990, 67) This confirms/supports behavior # 4, gathering adequate data before hypothesizing.

Sherlock

With Sherlock, Lesgold et al. establish a coached practice environment to train diagnosis and repair of the F-15 Manual Avionics Test Station. The test station itself is used to diagnose failures of navigational equipment on the F-15 aircraft. However, when the test station fails, it must be diagnosed and repaired by a human technician. The system's goal is the development and refinement of mental models to enhance the student's problem solving and inductive learning skills. (Lesgold et al., 1992, 51, and Towne and Munro, 1991, 328)

Lesgold et al. integrate intelligent simulation and training technology with principles of apprenticeship. These principles are that: students learn by doing, the acquired knowledge is anchored in experience, and skill development is supervised by a tutor with expert knowledge. Simulation and training technology are used to allow the trainee to perform the task he is trying to learn. With respect to just having exercises to practice in a classroom, students are more motivated to learn when they have physical tasks to accomplish with actual tools. Additionally, this hands-on application "anchors" the knowledge that is acquired in personal experience. In turn, this enhances recall of the knowledge chunks and subsequent performance. (Lesgold et al., 1992, 50)

An intelligent system is used to provide the trainee expert support and coaching. Specifically, the tutor assists "in the delicate period during which a trainee knows more or less what to do in a problem situation but is unable to keep track of his efforts because each requires focused attention to be carried out successfully, coworkers and 'masters'

become supportive external memories that share the attentional load while still affording opportunities for practice." (Lesgold et al., 1992, 49 through 50) The result is a "situated learning approach that fosters conceptual abstraction via coaching and comment upon specific problem situations." (Lesgold et al., 1992, 57)

Sherlock's intelligent tutor coaches the student's problem-solving performance, assesses student strengths and weaknesses through model tracing, and assigns progression problems based upon the assessments. (Lesgold et al., 1992, 51) An analysis of this system reveals that the problem solving strategies are an adaptation of Inquiry theory. The students that train with Sherlock have a basic working knowledge of electrical circuitry. Thus, the students are not novices and know most of the factors that may cause, or combine to cause, a system failure. Sherlock teaches the student to efficiently find and diagnose the failure. In terms of Collins' Inquiry theory, it accomplishes this by requiring the student to *form a hypothesis* about the location of the failure, *test the hypothesis*, and repeat the steps until the location is determined. The student can consult the tutor to debug his hypothesis by *tracing consequences to a contradiction*, *considering alternative predictions*, *varying cases systematically*, and establishing (*selecting*) *positive and negative exemplars*. Lesgold et al. refer to this interaction with the tutor as "reflective follow-up." (Lesgold et al., 1992, 57 through 58) This process is repeated for diagnosing the cause of circuit

failure once the location is determined. By employing Inquiry strategies, the student is able to realize the factors that indicate the location and nature of a failure in the test station.

Sherlock's tutor monitors five basic student behaviors. These behaviors are listed in Table D-2, Student Inquiry Behaviors Monitored in Sherlock.

Table D-2, Student Inquiry Behaviors Monitored in Sherlock

Behavior	Description	Corresponding Inquiry Strategy
Swapping vs. testing	Student does not swap a component until he has proven that it is defective.	Testing hypotheses Varying cases systematically
Redundant testing	Student systematically tests components such that none must be tested twice.	Testing hypotheses Varying cases systematically
Accepting help	Student asks for help when needed. He compares his approach or solution to that of the tutor.	Considering alternative predictions Tracing consequences to a contradiction Selecting positive/negative exemplars
Independence and self-confidence	Student does not ask for help when not needed.	None
Systemticity	Testing efficiency; student restricts the fault search to the relevant circuit path.	Testing hypotheses

Lesgold et al. have developed a second generation system, Sherlock II, that has not yet been tested with students. However, the first version, Sherlock, has been tested

for its effect on learning. The effect Sherlock had on training was determined by measuring pretest–posttest change and is even more remarkable than that of Smithtown. Lesgold et al. found that 20 to 25 hours of Sherlock practice time produced average performance improvements that were commensurate with the effects of 4 years job experience. (Lesgold et al., 1992, 54) While these results seem incredible, the learning gain from Sherlock's approach was independently verified with 32 college students. Johnson et al. (1993) found that the tutorial group showed a 78% improvement (in actual troubleshooting success) over the control group.

Although testing a large number of circuit boards seems like a mundane, time consuming task, it is a relevant example for an AAR. The location and correction of faults in the test set requires the knowledge of a number of different factors and their relationships. While the actual testing methods (using an oscilloscope or multimeter) are simple tasks, the student must: 1) consider what the test station was trying to do when it failed, 2) develop a mental representation of the circuitry involved in the failed function, and 3) develop a plan for testing that functional circuit. Otherwise, the student is left searching tens of thousands of parts for the fault. (Lesgold et al., 1992, 51 and 52) Essentially, the student must learn the cause and effect relationships between components and the troubleshooting methodology used by the system to narrow the choices for the fault location. Then, the student must develop an efficient circuit test plan to verify his hypothesis. The better he understands the factor relationships, the sooner he will isolate and correct the problem.

Like the airmen trained on Sherlock, AAR participants have different levels of expertise with differing levels of realization about factor relationships. Collectively, the unit is not at the novice level. What Sherlock has shown is that immense performance improvement can be made by focusing the students on the problem and aiding them in discovery of the factor relationships specific to that problem.

Self-elaboration is considered to have a strong positive impact on learning even though its effect has never been empirically isolated in that respect. In previous learning experiments, elaboration has always been confounded with one or more factors. (Williams, 1996a) Notwithstanding, ACT-R (Anderson, 1993) and the general theory of problem solving (Simon & Newell, 1972) provide a clear and plausible theoretical basis for the premise that one learns by analogy via elaboration. Both Smithtown and Sherlock demonstrate and support this premise. Both systems employ versions of Inquiry theory to explain learning points to the student, keep the student focused on the learning point until he understands it, and then require him to apply or demonstrate the learning point. The mechanism that allows the student to understand the point is iterative elaboration of experience. In the end, self-elaboration becomes synonymous with mental practice.

APPENDIX E

PROPOSED DESIGN

The proposed design builds upon existing AAR systems and efforts that support small unit training systems. Previous simulation training AAR systems, as well as R & D efforts, have the goals of thorough performance data collection and the facilitation of data manipulation for ease of preparation and presentation. (Chapter III and Appendix C, Current AAR Systems in Training Simulations) This design does not discount these efforts but describes the components and processes needed to conduct an effective AAR. Where current AAR systems' functionality stops with the display of performance data, the proposed system requires participants to interactively manipulate the data during the AAR. Trainees interact with each other and manipulate the performance data in accordance with the Inquiry process presented in Chapter IV. Figure E-1 shows the physical components of the proposed AAR design.

Component Functionality

Control Station

The control station is the AAR leader's interface with the data collection subsystem, Inquiry tutor, and testing component. It is a menu driven, graphical user interface (GUI) that allows the leader to input: data and commands into the collection

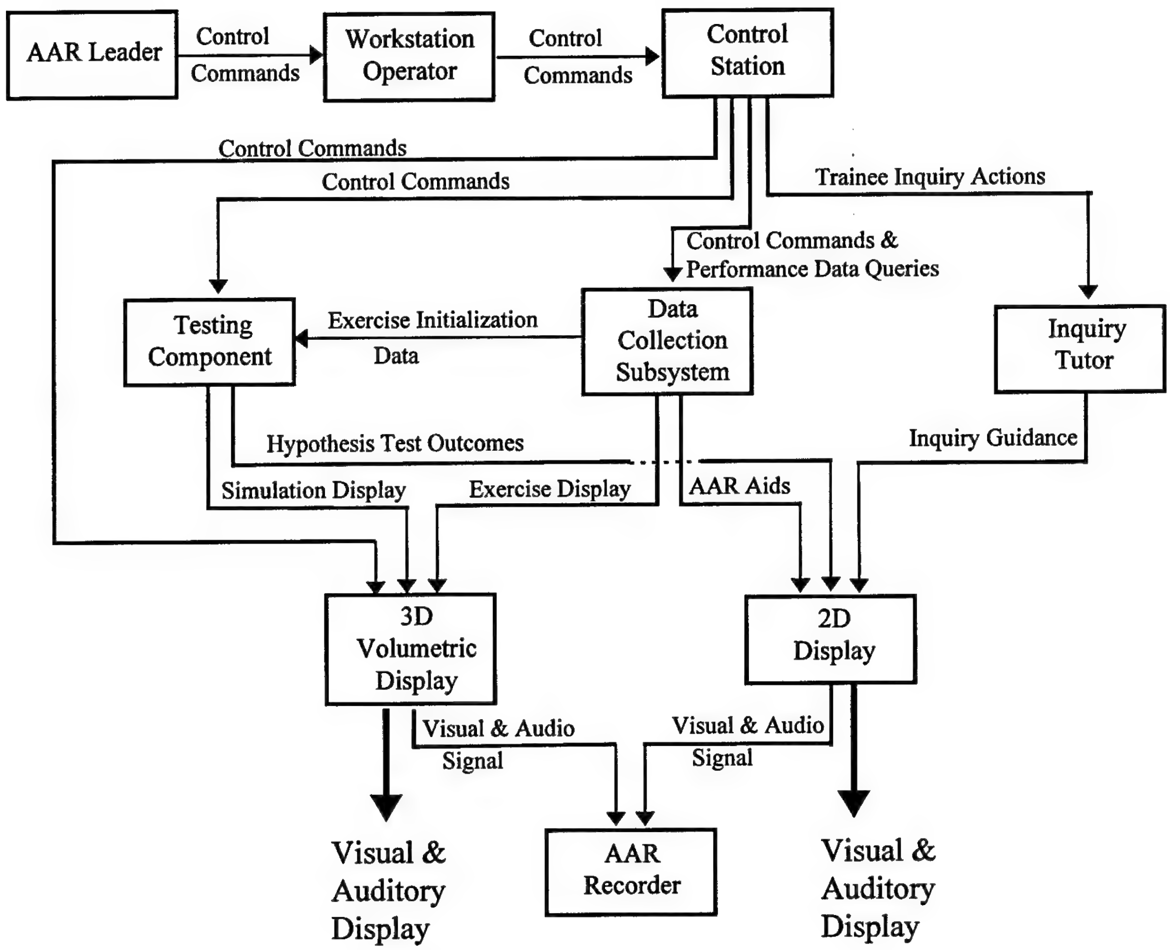

Figure E-1, Proposed AAR System Design

subsystem, Inquiry strategies into the Inquiry tutor, and test parameters into the testing component. Also, the leader controls the 2D and 3D displays from the workstation. The AAR leader works through a workstation operator who can devote full attention to the GUI and the creation of the needed displays during the AAR. The operator is needed

because 1) four different components must be controlled, two of which the trainees must interact with during the AAR; and 2) the AAR leader's primary responsibility is to monitor the discussion, from which interaction with a GUI will detract.

The workstation must allow the AAR leader to control the data collection subsystem and the Inquiry tutor during the AAR in response to discussion queries and clarification needs; for example, what happened at a specific time and location in the training exercise. The AAR leader must also have the capability to control the testing component and its display output from the workstation. These requirements mean that workstation and AAR system responses are in real time and do not delay the AAR discussion. Exercise replay and test control must include the capabilities to fast-forward, reverse, pause, advance/reverse by time step, and advance/reverse by event.

Data Collection Subsystem

The Data Collection Subsystem component must be STAARS compliant because it will be implemented by the year 2004. (BCTD, 1996a) Notwithstanding, the proposed AAR system is not dependent upon any one of the exercise data collection systems (CCTT, UPAS, ATAFS, STRIPES) that were reviewed in Chapter III and Appendix C.

Whatever form this subsystem takes, the AAR leader must be able to present a selection of problem issues as well as potential dependent variables to the trainees. To do this, the collection subsystem must collect and format performance data associated with collective and individual task standards. Other sources that help to determine what

problem to solve during the AAR are the training plan (objectives), the senior trainer, OC observations, and OPFOR observations.

As long as the data collection subsystem is STAARS compliant, the system will be able to collect performance data, make it available to an operator for manipulation, and then arrange it into one of the standard formats. For example, if the training objective is to perform the collective task *Perform Overwatch/Support by Fire* to the standards outlined in ARTEP 7-8-MTP (DA, 1994), then the trainees may want to review the data associated with the task standard: "The platoon delivers suppressive fires to prevent enemy direct fires from fixing the movement element" (DA, 1994, 5-18); assuming this standard was not met. The data collection subsystem would then need to provide a sequence of time-stepped battle sets (Table C-1, STAARS AAR Products Supporting Maneuver) depicting the overwatch element, the maneuver element, and the enemy forces during the period of the assault or maneuver bound. As each battle set is reviewed, the enemy positions that place direct fire on the friendly force and the casualties that result should be highlighted by the AAR leader or trainee unit leader. The discussion then begins on how the support element can suppress the enemy that caused the friendly casualties.

As one can see, the battle sets must be readily available for presentation. If the training objective is used to guide AAR preparation, then this data and format will not be a problem. If the data collection subsystem is STAARS compliant, the battle sets will either be automatically generated or readily available for generation.

Presentation Medium

The critical requirement for the presentation medium is that it be clearly seen by all participants during the AAR. The AAR presentation medium for existing AAR systems and systems under development is a large cathode-ray tube (CRT) monitor – a large screen television. (Appendix C, Current AAR Systems in Training Simulations) The proposed system employs this same screen for the same purposes: to present 2D and 3D animated exercise replay, battle sets and sketches, statistical summaries, word slides, and any other standard format designated by STAARS. (Appendix C, Current AAR Systems in Training Simulations)

The medium must be clearly seen by all the AAR participants seated around a terrain model. (See Figure E-2, Physical Layout) With groups as large as 40 , there will need to be at least two screens to accommodate everyone. A single screen large enough to be clearly seen across a room will be too large to view comfortably from the near side of the room.

An alternative to the two screen option is a movie theater approach. This places the viewing screen at a distance from the audience while allowing comfortable viewing from both near and far positions. This means that the room must be enlarged and the projection system changed for all current AAR systems as well as those in development.

Discussion Mediums

Discussion mediums are tools that facilitate trainee and AAR leader articulation and elaboration during discussion. There are two principal mediums in the proposed AAR system: the terrain model and the whiteboard/chalk board. Each must be located so that all participants can see and have access to them. This means that the participants are positioned around the terrain model with the whiteboards positioned around them. (See Figure E-2, Physical Layout)

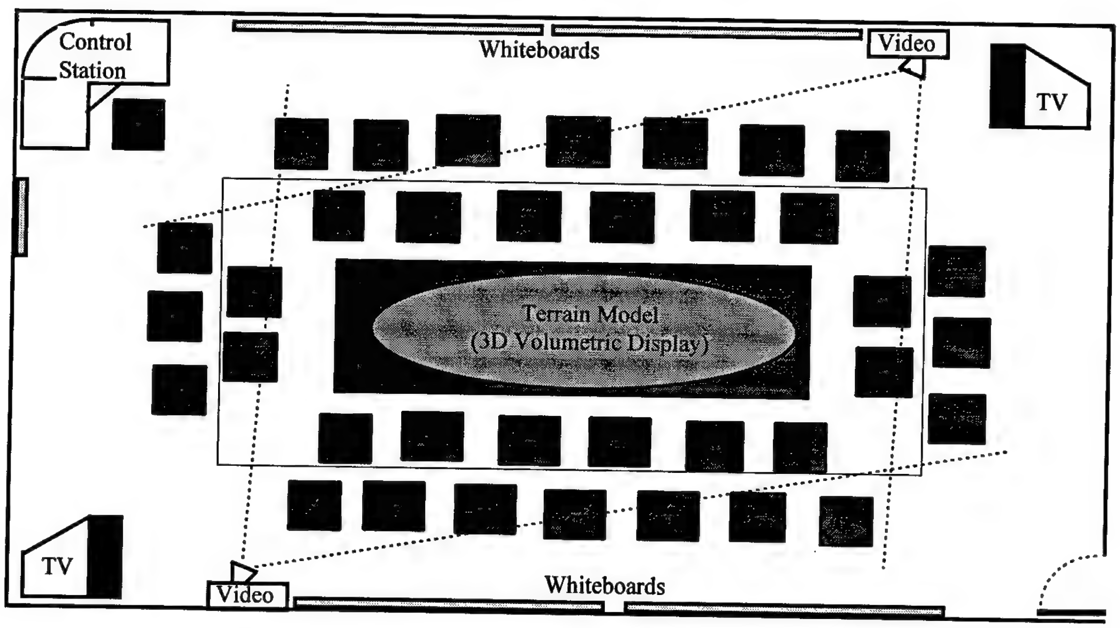

Figure E-2 , Physical Layout

The central location of the terrain model is necessary so that it becomes the focus of discussion. In this arrangement, it is more difficult for a single person to lecture to the group because he is not positioned to monopolize the group's attention.

The terrain model is a scaled model of the battlefield where the action being discussed took place. Weapons, equipment, vehicles, units, and individual people can be represented with corresponding scale models. However, the scales must be large enough for all the participants to distinguish individual piece characteristics. For example, the trainees must be able to visually differentiate between types of vehicles and dismounted soldiers.

A 3D representation is needed to accurately model entity time-distance relationships and the physical features of the terrain. The entity time-distance relationships allow the trainees to quickly visualize the relative force dispositions. These relationships are constantly assessed against an analysis of the terrain. The terrain representation allows the trainees to uniformly interpret the terrain cues and considerations. Accurate assessment and advantageous use of cover and concealment offered by the terrain are often major factors in a fire fight.

Because the discussion will involve different actions at different times, this medium must have the capability to represent a number of locations and unit situations – the terrain model must be re-configurable in real time. Furthermore, the re-configuration of the terrain model should not take longer than one minute in order to help participants demonstrate discussion points with the medium. Since a permanent terrain model cannot be reconfigured to represent different locations of the battlefield and a sand table would take too long to make, a technological solution is needed. These requirements are

satisfied by a new display technology known as Laser-Based 3 Dimensional (3D) Volumetric Display System. (Soltan et al., 1995)

The Laser-Based 3D Volumetric Display System was developed by Parvis Soltan under a contract from the Naval Command, Control and Surveillance Center. The system allows a person to view, with the naked eye, color 3D images that are updated in real time to create a scene in a volume image space. A cylindrical volume image is created by incorporating a 36-inch diameter double helix that spins at 10 revolutions per second. A computer controlled laser beam illuminates discrete volume points (voxels) on the helix. The voxel is the 3D counterpart of the pixel. The helix scatters the laser light so that each voxel appears to emanate from a specific point in space. To create a scene, up to 40k laser-generated voxels are projected onto the reflective surface of the rotating helix using the Acousto-Optic Random-Access Scanner. These voxels are refreshed at a rate of 20 Hz per color. Each point in the cylindrical volume has an x, y, z coordinate address stored in the computer. The computer then synchronizes the laser beam, the Acousto-Optic (AO) Scanner, and the phase of the helix to illuminate a set of points and create an image. (Soltan, 1995, 1) The capability to display 3D images that can be viewed from any side of the display volume makes it ideal for exercise replay and testing component display.

An alternative to the Laser-Based 3D Volumetric Display System is the Mirage. The Mirage is a 3D, stereoscopic, pseudo-holographic display system built by Scott Smith of the Institute for Simulation and Training (IST), University of Central Florida

under a contract funded by STRICOM, the Defense Modeling and Simulation Office, the Army Research Institute, and the University of Central Florida. (Smith & Garnsey, 1997) The term "pseudo-holographic" as a descriptor refers to the hologram-like image the system produces. It does not use true holography. Overall, the system projects a 3D scale model image onto a horizontal projection table. This allows the viewer to walk around the image and zoom in and out. A hand-held joystick allows the viewer to pan through adjacent scenes in the database.

The Mirage receives scene database PDUs via both Ethernet and FDDI network interfaces. The system consists of an image generator that provides stereo output at 60 right and 60 left eye images per second to an Electrochrome Marquee™ 8110 series projector. A trapezoidal mirror bends the projected image to a vertical path onto the projector screen laid on a horizontal table. The viewer wears StereoGraphics Corporation CrystalEyes 2™ glasses to see the time-multiplexed right and left eye images projected upon the screen. The glasses are field sequential electro-stereoscopic liquid crystal shutter devices synchronized by an extended range infrared transmitter mounted above the table. The IR transmitter receives its signals from a serial port on the image generator. When a right eye image is being drawn, the glasses occult the left eye and vice versa. The viewer's position, relative to the table screen is determined by an Ascenscion Technology Corporation Flock of Birds™ magnetic position sensor and transmitter. The sensor (receiver) is worn on the viewer's head while the transmitter is mounted beneath

the center of the table screen. The viewer controls the display through a keyboard, mouse, and SpaceBall^{tm} joystick.

The principal drawback of the Mirage system is that it will only allow a maximum of two viewers per table screen. These viewers must be within a 10 degree viewing angle of each other to avoid distortion of the image. A single viewpoint can be transmitted to a number of glasses, but the networked viewers are at the mercy of the viewer with the position sensor. His head movements will most likely give the rest motion sickness.

Whiteboards with color pens are for participants to sketch concepts, take notes, and communicate ideas during discussion. The boards are equipped with electronic scanners so that their contents can be transferred to paper copy as needed. This component records the written discussion notes for the unit's take home package and reduces trainee discussion inattention caused by trying to copy everything from the board to a notebook. In most of the AARs surveyed in Chapter III, a unit member was employed to take notes on the AAR leader's whiteboard during the discussion.

Drawing pictures helps participants articulate their argument and helps others visualize and understand the idea. The medium is also used to annotate discussion notes. In this case, it works as a working memory aid. As participants brainstorm, the ideas are written on the board for later assessment. Key principles and relationships are written and updated on the board so that participants can concentrate on deriving or

understanding new rules and do not have to remember everything that was stated previously.

The whiteboard medium is particularly useful in actively engaging trainees in the discussion to achieve a collaborative effort. By making reluctant unit members move from a passive sitting position to writing on a board, they are induced to take a more physically active role in the AAR. This activity is the first step toward constructively contributing to the discussion.

Inquiry Tutor

The Inquiry tutor component is the expert knowledge base for Inquiry theory. The tutor maintains Collins' Inquiry strategies and procedures in a knowledge base. This procedural knowledge base monitors a model of trainee problem solving actions in the same manner as Shute and Glaser's Smithtown (Appendix D). From a comparison of expert actions and trainee actions, the tutor offers guidance and coaching of the Inquiry approach for AAR participants.

The tutor keeps a detailed record of all trainee inquiry actions and categorizes them as either behaviors or solutions. The tutor then diagnoses solutions by comparing the trainees' solutions to sets of actions or non-actions stored in the procedural knowledge base. These sets constitute optimal and sub-optimal behaviors. The sets of behaviors are essentially proper and improper sequences of Inquiry actions. The

differences between the two models form the basis of the Inquiry approach coaching for the group. (Shute and Glaser, 1990, 53 and 54)

The Inquiry tutor will rely on the AAR leader to input the trainees' Inquiry actions at the control workstation. The tutor's coaching will then be displayed on the presentation medium to guide the discussion.

Testing Component

The testing component of the proposed AAR system is used to test trainees' hypotheses about factors that affect performance outcomes. The testing component must be a constructive simulation of situational exercises devised by the trainees and capable of faster than real time simulation. This speed is necessary to prevent the running of the simulation from distracting and delaying the AAR participants and discussion respectively. The discussion focus must remain on the hypothesis and its factor relationships during the test. After the test, the discussion must refocus on why the hypothesis is untrue or cannot be proven untrue.

The constructive simulation must be initialized with the same parameters as used by the training system. The simulation situation parameters are the factors that are manipulated by the trainees to discover interrelationships. These are then input into the simulation by the AAR leader. The trainees must also specify the measure of performance/outcome, the dependent variable, that will dictate whether the hypothesis is to be accepted or rejected. Hence, the testing component must be able to simulate

objective actions and quantifiable results of a battle and output those results to a display system.

The testing component is controlled by the AAR leader and has the following control features: play, fast-forward/reverse to the next time step, fast-forward/reverse to the next event, and pause. Additionally, the component should allow the test simulation to be started at any point in the simulation. These features are available by a window menu from the control workstation.

If the output is process or situation based, the output should be displayed on the Laser-based 3D volumetric display system. In other words, the 3D volumetric display is used if the measured outcome is dependent upon creating specific enemy-friendly time-space relationships. This will focus attention on the results of the test. It also helps the trainees perceive the test as valid because the actions portrayed in 3D images looks realistic and similar to the replay of their original training exercise. If statistical in nature, the simulation output should be displayed on the 2D presentation medium.

AAR Leader

As in all other AAR systems, the AAR leader in the proposed system is responsible for complying with the doctrinal requirements outlined in FM 25-100, FM 25-101, and TC 25-20. (Chapter I, 16 through 24) However, the proposed system provides more resources for the AAR leader to accomplish this guidance. The Inquiry tutor, a responsive 3D display system, and the control station operator combine to reduce

the workload of the AAR leader. Still, the AAR leader must brief the purpose and objectives of the AAR and begin the discussion. Once started, the AAR leader can devote himself to increasing participation in the discussion and allow the Inquiry process to focus and guide the discussion.

The mission of the AAR leader is to prompt, monitor, and reward discussion participation in order to increase the effectiveness of the AAR. He does this by establishing participation as an objective of the AAR discussion in the introduction and providing participation feedback to the group and individual trainees. He prompts the use of the discussion mediums to engage trainees who are hesitant and/or cannot articulate their point in the discussion. At the same time, he monitors the discussion to determine if most of the trainees are contributing. If someone can contribute to the discussion and is not doing so, he solicits their comments and then encourages future participation with laudatory remarks.

While enhancing participation, the AAR leader has four other responsibilities that also require him to monitor the discussion. These responsibilities are the control of: the data collection subsystem, the Inquiry tutor, testing component, and AAR summary.

The first is to control and input information queries into the data collection subsystem to support the AAR discussion. Initially, the AAR leader will present a choice of problem areas for the trainees. These potential discussion issues are derived from the data associated with the performance standards of the collective training tasks; the BDA or results from the exercise. The training tasks are specified in the unit's training

objectives. This provides the trainees a choice of discussion starting points. Also, the AAR leader presents information on the different variables and factors that are being discussed in an effort to reveal what influenced those variables and factors and help trainees to establish cause and effect relationships.

The control of the presentation medium is an implied task that follows from inputting requests to the collection subsystem and trainee inquiry actions to the tutor. Obviously, the AAR leader is responsible for what is displayed on the presentation medium. Therefore, he must interpret, articulate, and elaborate the information presented for the trainees. The data collection subsystem output, Inquiry tutor output, and hypothesis testing results are the three basic categories of information presented on the presentation medium.

The AAR leader's second responsibility is to control the input of trainee actions into the Inquiry tutor. Overall, the AAR leader implements the *questioning authority* Inquiry strategy (Chapter IV, 165) to make participants self-reliant in problem solving discussion. He must be capable of articulating and elaborating the inquiry process by providing the appropriate Inquiry strategy as an example for the trainees. The AAR leader can: *select positive and negative exemplars* and *vary cases systematically* to demonstrate the relationship between relevant factors and show how factor relationships are constructed into a rule. This responsibility requires a working knowledge of the Inquiry approach.

The AAR leader's third responsibility is to input the variable parameters and run the testing component to test hypotheses. The AAR leader also must determine if the variable parameter adjustments to *vary cases systematically* or *consider alternative predictions* are realistic. This determination is made by considering the hypothesis itself and the purpose of the test. For example, assume the hypothesis is that the movement formation affects the number of casualties received in the initial contact with an enemy. Then, different movement formations should be tested against the same enemy formation, terrain, vegetation, and visibility conditions as given in the original training exercise. The movement formation is the factor that is varied systematically while other variables and factors are held constant. The trainees should not be able to degrade the enemy force nor decrease visibility unless the purpose of the test changes. An appropriate purpose might be to discover how those variables interrelate with movement formation to affect friendly casualties.

The AAR leader must also guard against the unrealistic adjustment of the parameters for testing. In other words, ground vehicles should not be able to fly or be given indestructible armor when the trainees *generate hypothetical cases* (Chapter IV, 160). Additionally, the AAR leader must ensure that the trainees are allowed to alter only the variables that they control. He will have to determine realistic from unrealistic adjustments because the trainees must also be allowed to generalize their hypotheses. Generalizing hypotheses entails testing hypotheses with other mission, enemy, terrain, troops, and time conditions (factors).

The AAR leader's final responsibility is to summarize the trainees' hypotheses and test conclusions. If the Inquiry process is properly implemented, the trainees will have identified the specific causes of performance outcomes and the situational training exercise parameters in which to execute re-training. These sets of task, conditions, and standards form the unit's future training plan and are the important results of an effective AAR.

Participants

The AAR participants are the unit trainees and the OPFOR unit leaders. There can be as many as 36 and as few as 8 trainees. The OPFOR leaders will range in number from 1 to 6. For company and platoon training systems, these participants will range in rank and experience levels from private to captain and from 1 to 16 years respectively.

All participants must be seated/positioned to facilitate discussion amongst themselves. Therefore, the participants must be seated facing each other and, at the same time, have easy access to each discussion medium. (See Figure E-2, Physical Layout) This means that the AAR leader is not the center of attention; everyone is not facing him throughout the AAR and he is not behind a podium nor on an elevated stage.

The OPFOR provide exercise information to explain what happened and why. This information is important in providing insight into variables and their relationships that affected performance. They do the same for OPFOR actions on the constructive simulation. There is a problem if the OPFOR are live trainees also. In other words, if the

training exercise consisted of two platoons in networked simulators fighting each other on a virtual battlefield, two separate AARs, one for each, may have to be conducted. In that case, leaders from each platoon could attend the other AAR if scheduled at different times.

The trainees use a guided inquiry approach to improve performance. The trainees also select the problem issue(s) on which to focus the AAR. The trainees select the problem topic(s) because they know their own strengths and weaknesses the best. They should select a recurring or systemic problem to discuss rather than a performance failure that occurred by chance. These are normally associated with the performance standards specified by the training objectives.

AAR Recorder

The AAR recorder component consists of a remotely controlled video camera and a VCR that record the AAR for the unit's take home package. The video camera is wall mounted and responsible for recording all discussion during the AAR. It also captures the sources of discussion on the videotape. The VCR records the information displayed on the presentation medium to videotape. Of special interest is the recording of the trainees' hypothesis formulation and testing (of *solutions developed*, Chapter III). Captured on video, the unit can later analyze the process for inquiry errors, factor relationship misconceptions, and faulty reasoning. However, most important of all are the problem solutions in the form of future training tasks, conditions, and standards

(*solutions planned*, Chapter III) that have been verified with the constructive simulation of the testing component.

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